EVALUATION OF JUVENILE FISH BYPASS AND ADULT FISH PASSAGE FACILITIES AT WATER DIVERSIONS IN THE UMATILLA RIVER

ANNUAL REPORT 1992

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EXECUTIVE SUMMARY

We report on our progress from October 1991 through September 1992 in evaluating juvenile fish bypass facilities at Three Mile Falls and Westland dams on the Umatilla River. We also report on our progress from October 1991 through June 1992 in evaluating adult fish passage in the lower Umatilla River and adult fish passage facilities at Three Mile Falls Dam. The study is a cooperative effort by the Oregon Department of Fish and Wildlife (ODFW) and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). These are the study objectives addressed by ODFW and CTUIR:

1. Report A (ODFW): To evaluate the juvenile fish bypass facility in the West Extension Irrigation District Canal at Three Mile Falls Dam and document juvenile salmonid passage through the juvenile fish bypass facility and east-bank adult fish ladder. To measure velocity and develop trap designs at Westland Dam.

2. Report B (CTUIR): To examine the passage of adult salmonids at Three Mile Falls Dam.

The study is part of a program to rehabilitate anadromous fish stocks in the Umatilla River Basin, including restoration of coho salmon *(Oncorhynchus kisutch)* and chinook salmon *(Oncorhynchus tshawytscha)*, as well as enhancement of summer steelhead *(Oncorhynchus mykiss)*.

Report A

Our evaluation of the juvenile fish bypass facility in the WEID Canal at Three Mile Falls Dam, documentation of smolt passage through the bypass facility and east-bank adult fish ladder, and pre-evaluation activities at Westland Canal produced the following highlights:

1. Net weighted injury rates of juvenile fish moving through the upper and lower bypass were low. Tests indicated that reduced headgate openings did not adversely affect fish condition; no detectable difference in smolt injury occurred between deep downwell pool depths (10 feet) and shallow downwell pool depths (4 feet).

2. During standard operation, fish did not appear to suffer delayed mortality as a result of traveling through the bypass facility; notable occurrences of delayed mortality were probably the result of handling, rigors of testing, and poor holding conditions.

3. In the upper bypass, travel time from upstream of the headgates to the sampling tank for 50% of the spring chinook salmon released was approximately 2.5 times less than for fall chinook salmon or summer steelhead. Median travel times for releases downstream of the headgates were lower than upstream releases and nearly identical for all three species.

4. We rarely achieved a 95% recapture rate from upper bypass releases for any of the three species. A 50% recapture occurred for most spring chinook

salmon releases, but only 44% of the releases of fall chinook salmon and summer steelhead.

5. In the lower bypass, the one-half hour recovery rate for fall chinook salmon was higher (91.8%) than that for spring chinook salmon (39%) at a 25-cubic feet per second (cfs) bypass flow. After one hour sampling, recovery rates of spring chinook salmon at a 25-cfs bypass flow were approximately two to three times recovery rates at a 5-cfs bypass flow.

6. For releases upstream of the headgates, spring chinook salmon recorded the highest diversion rate (74.4%) as opposed to summer steelhead (55.3%), or fall chinook salmon (42.5%).

7. Fall chinook salmon fry leakage through, and impingement on, the traveling screen was less than 1% for the pumpback bay operations tested. Mean fork lengths of fall chinook fry used in the traveling screen leakage and impingement tests were transitional between fry and fingerling (64.5 mm - 70.7 mm).

8. Evacuation of water from the pumpback bay at river-return drain pipe openings of 20%, 30%, and 40% generally produced higher sweep velocities across the face of the traveling screen than operating canal pumps singularly or in tandem. Operating the canal pumps singularly or the drain pipe at a 20% opening produced approach velocities that met National Marine Fisheries Service screening criteria. Canal pump #2, operated alone, produced a more uniform intake pattern of water through the traveling screen than pump #1 operated alone.

9. Current velocities in the bypass channel were reduced by approximately 42% when operating canal pumps singularly versus in tandem. A 20% open drain pipe produced current velocities slightly (3%) above a design flow of 2-feet per second (fps). When the drain pipe was open 30% or more, excessive (> 2.0 fps) bypass channel velocities were recorded.

10. Smolt passage at the WEID Canal juvenile fish bypass increased rapidly in early April, 24 hours after river flow increased.

11. A minimum of 150,000 juvenile salmonids passed downstream through the east-bank ladder facility at Three Mile Falls Dam from 4 March to 27 June 1991. But approximately twice as many juvenile salmonids passed downstream through the adult ladder (74,131) as compared to the juvenile bypass (38,996) at this dam from 23 April to 9 May 1991. This greater use of the adult fish ladder by smolts, compared to the juvenile fish bypass, did not appear to be associated with canal or river flows.

12. Sweep velocity measurements taken at the Westland Canal drum screens were near or above 1 fps at drum screens 1 through 7 and at or below 1 fps at drum screens 8 through 10. Measurement of the approach velocity demonstrated that flow was uneven through the drum screens when velocities were greatest at 80% of water depth and low or negative at 20% and 50% of water depth. Approach velocities were below 0.5 fps at 98% of the sampling locations.

13. We designed two fyke nets for each of the 10 drum screens at Westland Canal for the drum screen leakage test. Each net is designed to be approximately 6-feet wide x 7-feet high at the mouth, 4 or 6.5-feet deep, and terminates with a l-foot x 1.5 foot cod end. We designed a fyke net for installation on the orifice plate downstream of each traveling screen for a screen leakage test.

Report B

Our examination of the passage of adult salmonids at and below Three Mile Falls Dam produced the following highlights:

1. While high frequency (150 MHz) radio telemetry equipment to conduct a radio tagging feasibility study was received in early June, no such studies were conducted in 1992 due to the late delivery and severe drought.

2. Seventy-five adult summer steelhead in excellent condition were counted in the west-bank ladder and trap during a brief operation in early December, representing 24% of the 313 total fish captured at both ladders during this time period. Severe problems continue to exist with trapping and hauling adult salmonids from the west-bank facility.

3. Mechanically-induced injuries to fall and spring chinook salmon at the east-bank facility were rare, except when fish were necessarily trapped in the top step of the ladder. Injuries observed on late spring chinook migrants (ventral abrasions and bruises) were probably a result of poor in-river passage conditions during very low flows (40 cfs).

4. Of the coho salmon trapped at the facility and released back at the river mouth, 11% returned to the facility within 2 days and 29% returned in four days.

5. A total of 107 dead adult coho salmon were sampled below Three Mile Falls Dam in 1991, comprising a greater proportion (5.8%) of the coho salmon minimum return to the Umatilla river than in previous years. Prespawning mortalities accounted for 43.2% and spawning mortalities accounted for 56.8% of the coho sampled.

6. Only 16 dead adult fall chinook salmon were sampled below Three Mile Falls Dam, representing a much lower percentage of the minimum return (3%) spawning below the dam than observed in previous years.

7. Of the spring chinook salmon return, less than 5% strayed in 1990 and 1991. Contributing to the good return and precise homing were adequate spring flows for attraction and passage, and juveniles acclimated and released at age 1^+ in 1986 and 1987.

8. Homing of adult fall chinook salmon was extremely poor when looking at 0^+ juveniles releases made directly into the lower river, but improved for upriver releases. Greatest homing ability (and reduced straying) was achieved when attraction flows were adequate and with juvenile salmonids reared to age 1^+, acclimated, and released upriver.

9. Stray rates for adult coho salmon (age 1^+ releases) varied between 6.0% and 47.3% from 1988 to 1991. A high percentage of these fish returned to the rearing facility (Cascade Hatchery), signifying that imprinting occurred at the hatchery.

10. Umatilla River fall chinook salmon are first harvested in the John Day Pool (Columbia River) in late August (peaking in mid-September) and enter into the Umatilla River by mid-October. Umatilla River flows exceeding 150 cfs prior to October do not always elicit an increase in migration numbers. Delayed migration from the Umatilla-Columbia River confluence to Three Mile Falls Dam is probably a result of both insufficient flows (<150 cfs) and high water temperature.

11. Coho salmon began migrating to Three Mile Falls Dam after mid-October in 1990 and 1991. They experience similar migration barriers and homing problems as do fall chinook salmon.

12. Run-timing of spring chinook salmon and summer steelhead to the Umatilla-Columbia River confluence is difficult to determine, given the small harvest rates in the Zone 6 (Columbia River) fishery. Entry timing and minimum flow requirements for migration to Three Mile Falls Dam are variable for summer steelhead.

13. Spring chinook salmon migrated to Three Mile Falls Dam at average weekly flows of 5,308 cfs to 40 cfs during the 1990-1992 return years.

REPORT A

1. Evaluate the juvenile fish bypass facility in the West Extension Irrigation District Canal at Three Mile Falls Dam.

2. Document passage of juvenile salmonids through the juvenile fish bypass facility and east-bank adult fish ladder at Three Mile Falls Dam.

3. Measure velocity and develop trap designs at Westland Dam.

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ABSTRACT

We report on our efforts from October 1991 through September 1992 to evaluate juvenile salmonid passage through the West Extension Irrigation District (WEID) Canal fish bypass facility at Three Mile Falls Dam on the Umatilla River. We also report on juvenile salmonid passage through the east-bank fish ladder at Three Mile Falls Dam and water velocity measurements in front of the traveling screen and drum screens at the WEID Canal and Westland Canal fish bypass facilities, respectively. We include fyke net designs for screen leakage tests at the Westland Canal juvenile bypass facility in 1993. Passage success was evaluated by injury and screen leakage tests. We also estimated travel time through facility components. Facility-caused injury to spring and fall races of chinook salmon (0. tshawytscha) and summer steelhead (0. mykiss) was low in all tests. Leakage and impingement of chinook salmon fry attributable to the traveling screen was 1% or less. Fall chinook salmon and summer steelhead released in front of the headgates were diverted into the canal at a lower rate and were slower to move through the upper bypass than spring chinook salmon. All three species of test fish released behind the headgates traveled through the screening facility at nearly the same rate. Test fish traveled faster through the lower bypass at a 25-cfs bypass flow than a 5-cfs flow. But even when the bypass is in operation, significant numbers of smolts are using the east-bank fish ladder as a route for downstream migration. Current velocities in front of the traveling screen at the WEID Canal fish bypass facility did not meet agency criteria during standard two-pump operations. At moderate canal withdrawals, current velocities in front of the drum screens at the Westland Canal were within agency criteria. While the WEID Canal fish bypass facility is effective at returning juvenile salmonids to the river, operational improvements are recommended.

INTRODUCTION

Large runs of salmon and steelhead once supported productive fisheries in the Umatilla River. By the 1920's, stream impoundments with inadequate passage facilities and habitat degradation had extirpated the salmon run and drastically reduced the steelhead run (ODFW and CTUIR 1989). However, a comprehensive fisheries rehabilitation program was initiated in the mid-1980's to improve passage facilities, fish habitat, hatchery production, and river flow. Improvements in salmon and steelhead runs in the Umatilla River are presently sufficient to provide a fishery for summer steelhead and, occasionally, spring chinook salmon, but are still well below long range production goals (ODFW and CTUIR 1990).

The Northwest Power Planning Council's Fish and Wildlife Program (1987) provided the impetus for fisheries rehabilitation projects throughout the Columbia River Basin (Section 1403, Measure 4.2). Reconstruction of ineffective passage facilities on the Umatilla River was a cooperative effort between the Bonneville Power Administration (BPA), Confederated Tribes of the Umatilla Indian Reservation, various fish and wildlife agencies, and the U.S. Bureau of Reclamation (USBR). These improvements included reconstructed or new fish ladders, state-of-the-art bypass facilities, newly designed canal screens, and at some locations, fish trapping and holding facilities.

Evaluation of passage facilities at irrigation diversions on the Umatilla River was recommended in *A Comprehensive plan for Rehabilitation of Anadromous* fish Stocks in the Umatilla River Basin (Boyce 1986). We have been evaluating the WEID Canal juvenile fish bypass facility at Three Mile Falls Dam since 1989 to determine if the facility returns fish to the river quickly and unharmed. Evaluations of similar fish screening facilities on the Yakima River, WA were used as a general model for our study design (Neitzel et al. 1985, 1987, 1988, 1990a, 1990b and Hosey & Associates 1988a, 1988b, 1989, 1990).

We operated the WEID Canal fish bypass facility in 1989 to test fish sampling equipment. In 1990 and 1991, we evaluated the general efficiency of the facility, conducted fish injury and leakage tests, and collected data on river-run fish (Knapp and Ward 1990, Hayes et al. 1992, Knapp 1992). Tests of injury and leakage showed that juvenile salmonids were not injured during passage through the bypass facility and that screening efficiency of the drum screens approached 100%. Impingement of subyearling fish and fry on the traveling screen was the most serious problem observed. We found that fish moved freely through the upper screening facility, but were delayed in the outfall at a bypass flow of 5 cfs. Findings from our evaluation studies have resulted in structural and operational improvements to the facility.

In this report we describe progress toward our third year study objectives which are to 1) continue evaluation of the juvenile fish bypass facility in the West Extension Irrigation Canal at Three Mile Falls Dam, 2) document juvenile salmonid passage through the juvenile fish bypass facility and east-bank adult fish ladder, and 3) conduct pre-evaluation activities at the Westland Dam and Canal.

STUDY SITES

Four major diversion dams are part of our long range evaluation efforts. State-of-the-art passage facilities have been constructed at Three Mile Falls, Maxwell, Cold Springs, and Westland diversion dams. Passage facilities at Stanfield Dam are due to be completed by 1993. Operation of Maxwell Canal will be terminated in the near future.

This year's progress report focuses on Three Mile Falls and Westland dams. Facilities at Cold Springs and Stanfield dams will be evaluated in future reports.

Three Mile Falls Dam is the lowermost dam on the Umatilla River, located at River Mile (RM) 3.0 (Figure 1). WEID diverts water through the canal to serve lands from Umatilla to Boardman, Oregon. New fish passage facilities were completed at Three Mile Falls Dam in 1988 (Figure 2).

The juvenile trapping and sampling facility includes two 10-cfs canal pumps which return water to the canal, a secondary traveling screen with a spray water system, an inclined screen and fish separator, and a transfer flume that carries fish to holding or sampling tanks (Figure 2). A restrictive orifice plate is placed in the bypass channel immediately downstream from the secondary traveling screen to reduce bypass flow to 5 cfs when sampling or trapping fish. The two canal pumps (or a river-return drain pipe) evacuate water from the pumpback bay. The secondary pumpback pump can return the 5-cfs bypass flow to the canal (USBR 1989).

Westland Dam is the third major diversion dam on the Umatilla River and is located at RM 27.3 (Figure 1). The Westland Irrigation District operates the Westland Canal to supply water to the west side of the river at the town of Echo. A reconstructed adult fish ladder, with an improved juvenile fish bypass and holding facility, was completed in 1990 (Figure 3). Juvenile fish entering the facility are either routed back to the river via a bypass pipe or diverted into a holding pond for trapping and hauling.

METHODS

Three Mile Falls Dam

Tests

We examined rates of fish injury, delayed mortality, travel time, diversion rate, and traveling screen leakage and impingement at the WEID Canal juvenile fish bypass facility. We increased the bypass downwell pool depth and decreased headgate openings to evaluate injury associated with nonstandard operations. In addition, varying modes of pumpback bay operations were tested during traveling screen leakage tests. We also examined passage of river-run smolts through the WEID Canal juvenile fish bypass and east-bank adult fish ladder at Three Mile Falls Dam (1991 data). Methods for tests conducted at standard operating criteria are described in detail in Knapp (1992). Standard (design) operating criteria defined by the National Marine Fisheries Service are included in Knapp and Ward (1990).

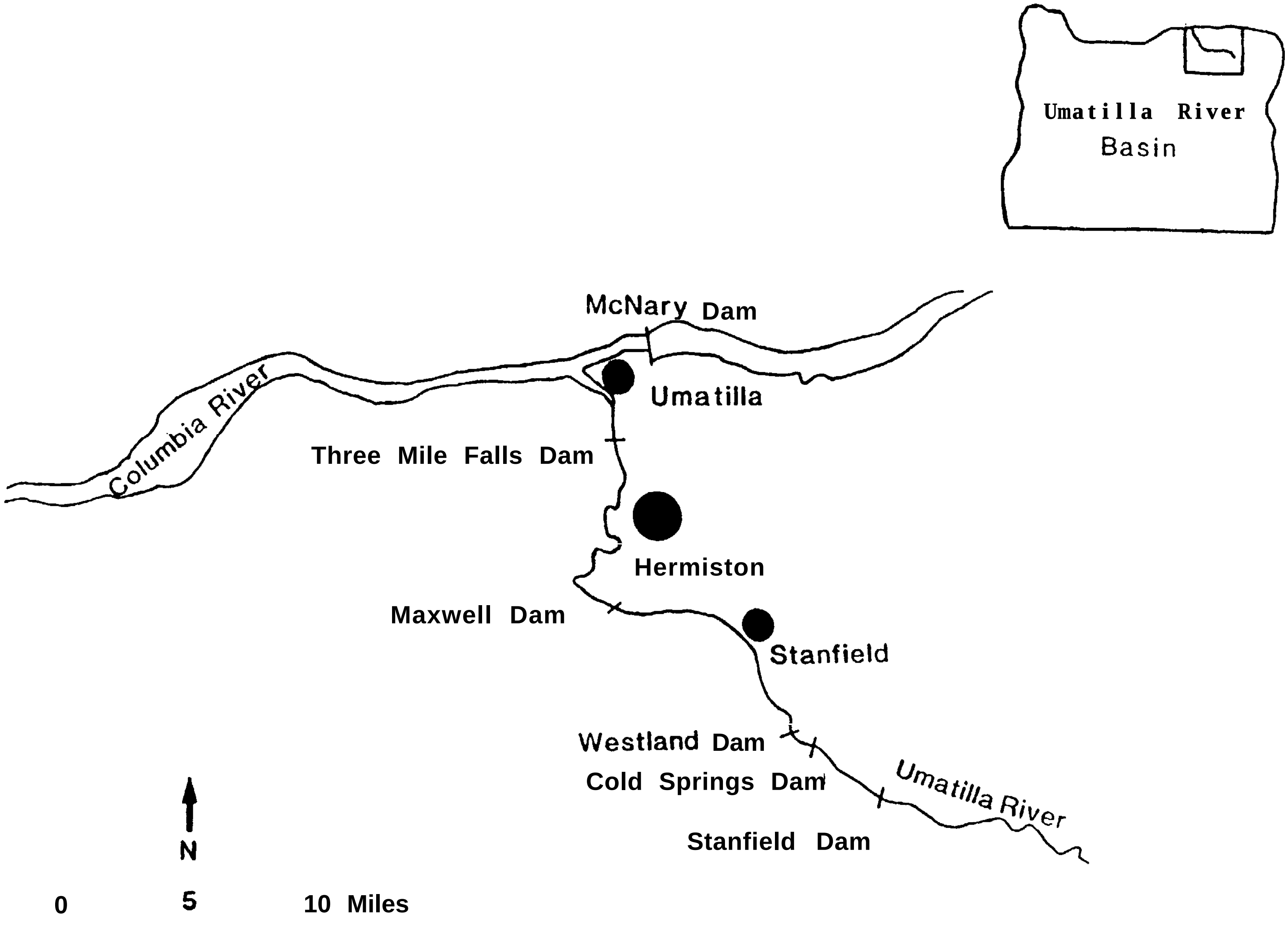
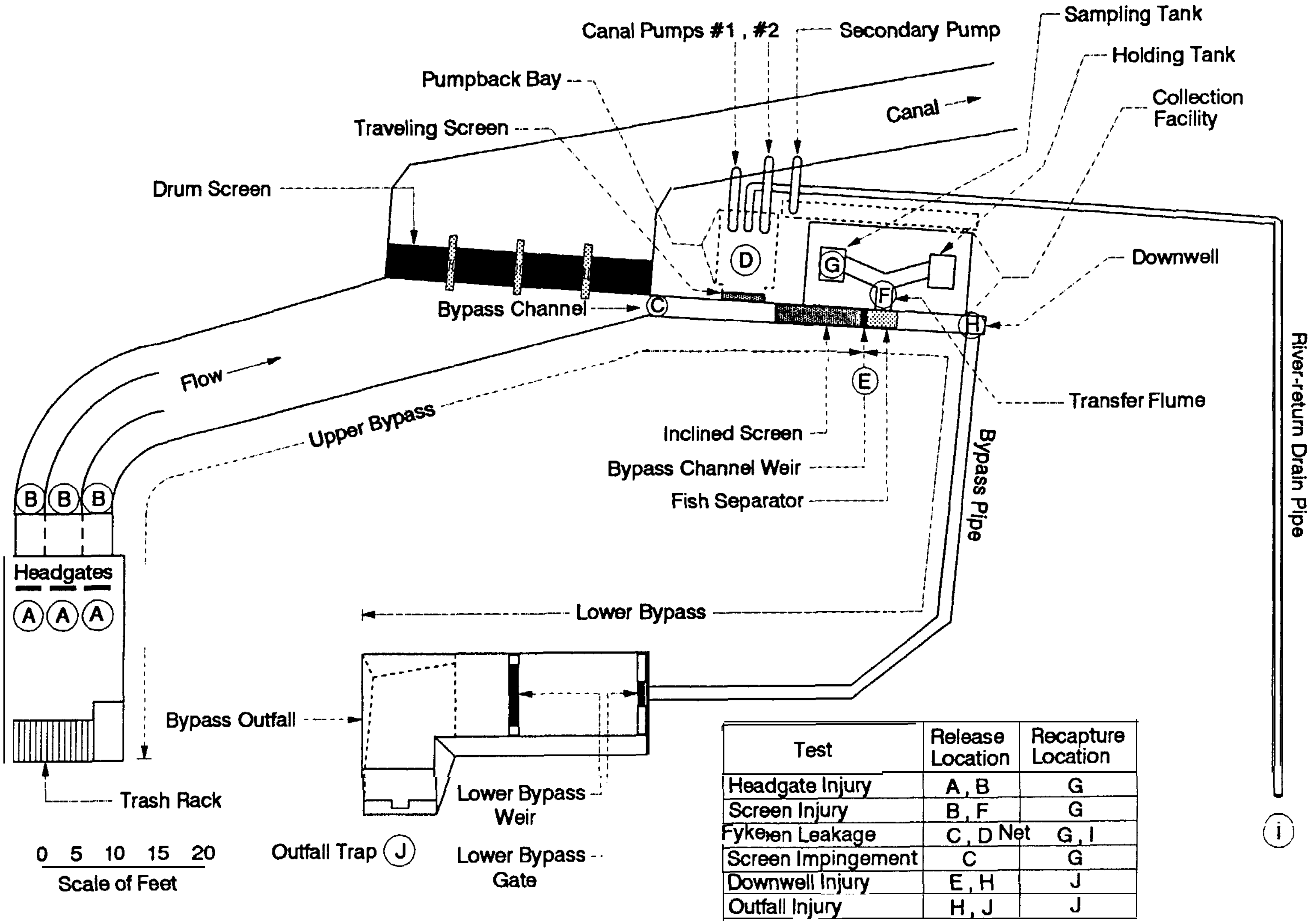


Figure 1. Locations of diversion dams on the lower Umatilla River, Oregon.



Test	Release Location	Recapture Location
Headgate Injury	A, B	G
Screen Injury	B, F	G
Fyke Net Leakage	C, D	G, I
Screen Impingement	C	G
Downwell Injury	E, H	J
Outfall Injury	H, J	J

Figure 2. Schematic of the WEID Canal juvenile fish bypass facility at Three Mile Falls Dam, Umatilla River, Umatilla River, including sampling locations for release and recapture of test fish.

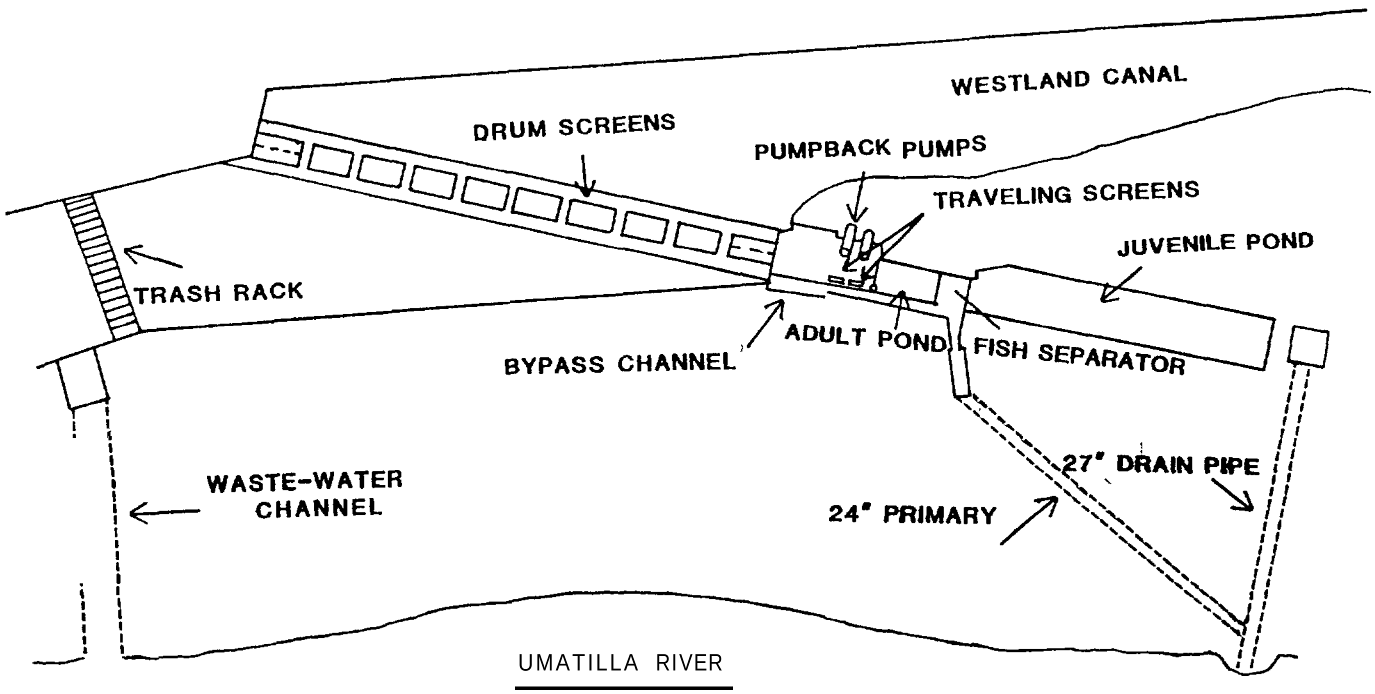


Figure 3. Schematic of the Westland Canal juvenile fish bypass facility at Westland Dam on the lower Umatilla River, Oregon.

Injury

Sampling Design: We conducted these tests with different species or races (sizes) of chinook salmon (0. tshawytscha) and summer steelhead (0. mykiss) in April, May, and June of 1992. Hatchery fish designated for release in the Umatilla River were used in all but one test. River-run subyearling fall chinook salmon were collected from the sampling tank for use in the outfall injury test.

Injury test fish were freeze-branded with a unique mark and held at least 72 hours prior to release. Test fish were handled in the same manner to reduce handling bias. Fish condition was determined using descaling criteria developed by the U.S. Army Corps of Engineers (Neitzel et al. 1985). Fish injured but not descaled were designated as "otherwise injured". Methods for fish marking and holding are described in Knapp (1992).

Injury tests included three replicate groups of marked treatment and control fish. Treatment fish were released upstream of the facility structure being evaluated; control fish were released either immediately downstream from the structure or in a recovery trap. Test fish were recaptured in the middle or at the terminus of the bypass facility (Figure 2). We used a modified sampling tank at the bypass collection facility as the midpoint recovery site and a floating net pen at the bypass outfall (Knapp and Ward 1990). Releases were repeated on either two or three separate dates. A 30% subsample was collected from each treatment and control group of fish to obtain an estimate of pre-test condition (injury) and mean fork length. Fork lengths were measured to the nearest millimeter (mm). Subsampled fish were not returned to their groups or included in any test releases. Each treatment and control group consisted of approximately 100 fish prior to subsampling.

Logistical differences in our recapture methods obliged us to sample treatment and control fish differently in the upper and lower bypass. We sampled test fish on a continuous basis from the sampling tank. In contrast, discrete samples were collected from the outfall trap. Upper bypass and lower bypass refer to the portions of the fish bypass facility above and below the bypass channel weir, respectively (Figure 2).

In the upper bypass, all three groups of test fish were released at approximately the same time. Control groups for the screen injury test were released in the transfer flume at three consecutive hourly intervals. Hourly sampling was conducted for 96 hours following the last release.

In the lower bypass, one pair of treatment and control fish were released on three separate occasions on each test date. The outfall trap was pulled to shore to process captured fish after sampling periods of one half hour and one hour for tests conducted at 25-cfs and 5-cfs bypass flows, respectively. During the first four releases of the 25-cfs downwell injury test, we used a one-hour sampling period, but high levels of injury associated with strong turbulence in the trap necessitated a reduction in the sampling interval. A transfer box with 20 feet of 2-inch diameter flex hose was used to release test fish at the start of the bypass pipe.

Facility-caused injury was evaluated by comparing injury rates of treatment and control fish after recapture. Test fish not recaptured during the sampling were not considered in the analysis. Pre-test injury rates were subtracted from post-test injury rates to standardize initial injury rates for each release group. Pre-test condition (from subsamples) and post-test condition (from recaptured treatment and control fish) was calculated for each release group as the percentage of uninjured, partly descaled, otherwise injured, descaled, and dead fish. We then weighted the percentages of uninjured, partly descaled, otherwise injured, descaled, and dead fish by multiplying by factors of 0.0, 0.33, 0.33, 0.67, and 1.0, respectively, to incorporate a qualitative measure of injury in the analysis. Weighting factors increased in even increments because this was the most objective method of reflecting the severity of each injury category. Weighted injury was then calculated for each pre-test subsample and post-test release group as the sum of the weighted injuries for all categories of injury. Net weighted injury was calculated by subtracting weighted injury of pre-test subsamples from the weighted injury of their corresponding post-test release group.

T-tests for the difference between two means were used to determine whether the mean difference in net weighted injury rates for treatment and control groups was statistically significant. We chose as our significance level (Q) a P value of <0.10 using a one-tailed test of significance. We computed a 95% confidence interval about the mean difference between treatment and control net weighted injury rates.

The T-test of paired differences was used for the headgate injury, downwell injury, and bypass pipe - outfall injury tests because each treatment and control pair shared common test conditions. For the screen injury test, we used a T-test for the difference between two means calculated from independent samples. The Cochran and Cox (1950) T-approximation for unequal variances was used in the analysis of the screen injury (night) test. All testing was completed using either the univariate or T-test procedures in the SAS program for personal computers (SAS Institute Inc. 1990).

Headgate Injury Test: We evaluated injury and mortality rates of fish passing through the headgates when less than full open to determine whether increased water velocity and turbulence would be injurious to fish. Tests were conducted with summer steelhead and spring chinook salmon yearlings and fall chinook salmon subyearlings from 7 April to 24 May 1992 (Table 1). Openings of each of the three headgates were reduced from 3 feet to 2 feet during tests with summer steelhead and spring chinook salmon and to 1 foot during the test with fall chinook salmon. Replicate groups of test fish were released simultaneously upstream (treatment) and downstream (control) of each headgate (Figure 2).

Screen Injury Test: We evaluated injury and mortality rates of fish passing through the upper bypass starting 6.7 meters (m) behind the headgates and ending at the transfer flume. Screens present in the upper bypass include the drum screens and traveling screen. Daytime and nighttime screen injury tests were conducted with yearling summer steelhead from 7 April to 13 April 1992 (Table 1). Day and night releases were made at approximately 1230 hours and 2100 hours, respectively. We followed normal bypass operating criteria for a sampling mode at the collection facility during testing (USBR 1989).

Downwell Injury Test: Injury and mortality to yearling spring chinook salmon associated with passage through the downwell at low and high pool depths was evaluated at 5-cfs and 25-cfs bypass flows. Respective low and high downwell pool depths were 2 feet and 10 feet at bypass flows of 5 cfs and 4 feet and 10 feet at bypass flows of 25 cfs. This test was designed to determine whether a higher downwell pool depth resulted in lower rates of injury for spring chinook salmon. The lower pool depths chosen are those observed during normal bypass operation at 5-cfs and 25-cfs flows. We conducted tests at each pool depth and bypass flow on two separate dates (Table 1). Three groups of treatment and control fish were released on each date. We released treatment groups at the crest of the bypass channel weir and control groups at the entrance to the bypass pipe, using the transfer box.

To increase the pool depth to 10 feet for the 25-cfs downwell injury test, we diminished the opening of the lower bypass gate. During the 5-cfs test, we completely closed the 1 ower bypass gate to back up water in the bypass pipe and downwell. When the water level in the downwell rose to a depth of 10 feet, we released one group of treatment fish while simultaneously raising the lower bypass gate. Approximately 40 seconds elapsed until the downwell pool returned to a depth of 2 feet.

Table 1. **Schedule of test fish releases for the** 1992 **evaluation of the** WEID **Canal juvenile fish bypass facility at Three Mile Falls Dam, Umatilla River.**

Species[a]	Test[b]	Release no.	Date	Release time	Canal flow (cfs)	Headgate opening (feet)
STS	HIT	1-3	7,8,9 April	1150 - 1244	37-76	2
STS	SIT-day	1-3	7,8,9 April	1150 - 1244	37-76	2
STS	SIT-night	1-3	7,8,9 April	2103 - 2108	37-76	2
CHF fry	TSLT-DP @ 40%	1-4	14 April	1030 - 1525	45	
CHF fry	TSLT-DP @ 30%	1-4	15 April	1100 - 1420	45	--
CHF fry	TSLT-DP @ 20%	1-4	16 April	1055 - 1430	44	
CHS	DIT-LP @ 5 cfs	1,2	27,29 April	0912 - 1334	--	--
CHS	DIT-HP @ 5 cfs	1,2	28,30 April	0910 - 1202	--	
CHS	DIT-LP @ 25 cfs	1,2	22,25 April	1045 - 1426	--	
CHS	DIT-HP @ 25 cfs	1,2	24,26 April	0908 - 1635	--	--
CHS	HIT	1-3	4,5,6 May	0912 - 1040	32-42	2
CHF fry	TSIT	1-4	6 May	1035 - 1335	42	--
CHF	HIT	1-3	18,19,20 May	0905 - 0910	52-69	1
CHF	OIT-LP @ 5 cfs	1,2	30 May, 2 June	0830 - 1215	--	--
CHF	OIT-LP @ 25 cfs	1,2	31 May, 1 June	0821 - 1213	--	--

[a] *STS = summer steelhead, CHF = fall chinook salmon, CHS = spring chinook salmon.*

[b] *HIT = headgate injury test, SIT = screen injury test, TSLT = traveling screen leakage test, DP @ 40% = river-return drain pipe open 40%, DIT = downwell injury test, LP @ 5 cfs = low (downwell) pool depth at 5 cfs bypass flow, HP = high (downwell) pool depth, TSIT = traveling screen impingement test, OIT = outfall injury test.*

Bypass Pipe - Outfall Injury Test: We evaluated fall chinook salmon subyearlings for injury and mortality associated with passage through the bypass pipe and outfall at bypass flows of 5 cfs and 25 cfs from 30 May to 2 June 1992 (Table 1). Releases were made on two separate dates for tests conducted at each bypass flow, adhering to standard operating criteria when performing the tests. During 25-cfs tests, we released the control groups directly into the outfall trap and installed the restrictive orifice plate to reduce bypass flow to 5 cfs during trap positioning (Figure 2). To reestablish a 25-cfs bypass flow before releasing the treatment groups into the start of the bypass pipe, we removed the restrictive orifice plate. Fish were released into the bypass pipe using the transfer box.

Delayed Mortality

Fish used in injury tests were held for 48 hours after recapture to assess the extent of delayed mortality caused by passage through the juvenile fish passage facility. We calculated the delayed mortality attributable to individual portions of the fish bypass facility to be the net delayed mortality (treatment minus control) in each injury test. We held all test fish recaptured during the first and second day of each injury test when holding space was available. Test fish recaptured in the sampling tank were held in 500-gallon circular tanks. Test fish recaptured in the outfall trap were held in a calm portion of the river in small net pens. We recorded the percentage of both treatment and control fish that were dead 48 hours after recapture.

Travel Time

We recorded release time and recapture time for test fish to examine fish movement through the upper bypass during the headgate injury and screen injury tests. We estimated travel time through the upper bypass by calculating the time to recapture 50% (median travel time) and 95% of the test fish released. We compared day versus night movements of summer steelhead through the screening facility by recording the percentage of treatment fish that were recaptured within four hours of release. We used a Kruskal-Wallis test with a significance level of $P < 0.05$ to determine whether differences in median travel time among test fish species were statistically significant. The Wilcoxon rank sum test, with a significance level of $P < 0.05$, was used to determine the statistical significance of differences in median travel time between summer steelhead released day and night. Nonparametric statistical analyses were used for the median travel time estimates because the data set did not meet the assumption of equal variances required by parametric tests. We estimated travel time through the lower bypass during the downwell injury and bypass pipe - outfall injury tests by computing the percentages of test fish recaptured after half-hour and one-hour sampling periods. We used a two-tailed T-test with a significance level of $P < 0.05$ to determine whether differences in percent recovery among test fish species were significant,

Diversion Rate

We estimated the amount of diversion from the river into the bypass as the percentage of test fish released above the headgates that were recaptured in the sampling tank within 96 hours of release. We used a Kruskal-Wallis test with a significance level of $P < 0.05$ to determine whether differences in diversion rates among test fish species were statistically significant.

Traveling Screen Leakage and Impingement

Leakage: Leakage of fall chinook salmon fry through the traveling screen was evaluated from 14 April to 16 April 1992 (Table 1). Tests were conducted when the river-return drain pipe was open 20%, 30%, and 40% and the canal pumps were off. Leakage during pumpback pump operation was not evaluated because of the inability to capture fish at the pump outflows.

Treatment consisted of releasing a total of 400 fry in groups of 100, at hourly intervals into the start of the bypass channel. A fyke net was attached to the terminus of the river-return pipe to collect test fish that leaked throuqh the travelinq screen (Knapp 1992). Frv that moved downstream past the traveling screen were recaptured in the' sampling tank. Serving as a control, one hundred fry were marked with bismark-brown dye and released into the pumpback bay at the start of each test to provide an estimate of fyke net efficiency.

Each drain pipe opening was tested over a 24-hour period. The fyke net was sampled at intervals of approximately 1 hour during the day and 2 hours at night. To collect the contents of the net, the drain pipe needed to be fully closed. Intermittent net repairs extended the amount of time that the slide gate remained closed.

Traveling screen leakage was calculated as the percentage of test fry that passed through the screen over a 24-hour period. We assumed that the total number of treatment fry that moved through and past the traveling screen was equal to the sum of those captured in the sampling tank (X_{st}) and drain pipe fyke net (X_{fn}), respectively. We assumed a capture efficiency of 100% for the sampling tank. Numbers of treatment fry captured in the fyke net were corrected for net efficiency. The formula for calculating the correction factor for fyke net efficiency (CF_{fn}) was

$$CF_{fn} = \frac{N_{pb}}{n_{fn}}$$

where

N_{pb} = the number of control fish released in the pumpback bay, and
n_{fn} = the number of control fish captured in the fyke net.

The formula for calculating percent traveling screen leakage (LK_{ts}) was

$$LK_{ts} = \frac{(CF_{fn})(X_{fn})(100)}{(CF_{fn})(X_{st}) + (X_{st})}$$

where

X_{fn} = the number of treatment fry captured in the fyke net, and
X_{st} = the number of treatment fry captured in the sampling tank.

Impingement: We evaluated the impingement of fall chinook salmon fry on the traveling screen while operating both canal pumps with the drain pipe completely closed on 6 May 1992 (Table 1). We followed the same release and recapture strategies used during the traveling screen leakage tests with the exception that control fish were not used in the impingement test. We estimated fry impingement by visual observation during daylight hours. We conducted observations from ground level, at the entrance to the bypass channel, in order to view the portion of the traveling screen underneath the spray.

Velocity

To evaluate the various modes of pumpback bay operation, we measured approach and sweep water velocities in front of the traveling screen and at the bypass channel entrance. We evaluated pumpback bay operations for the following conditions: (1) with the river return gate 20%, 30% and 40% open and both canal pumps off, and (2) with the river-return drain pipe closed and the canal pumps operating, each singly and both together. A Marsh McBirney (model 201 D) flow meter was used to record current velocities in feet per second (fps) at 20%, 50%, and 80% of water depth. For recording sweep velocities, the probe was positioned parallel to the screen and pointing upstream; for recording approach velocities, perpendicular to the screen and pointing away. Measurements were also taken close to the traveling screen along vertical transects at the middle of the screen and 8 inches from both the upstream and downstream edges of the screen. All measurements were taken along the vertical midline of the entrance to the bypass channel.

River-run Juvenile Salmonid Passage

River-run juvenile salmonid passage through the WEID Canal juvenile fish bypass facility was recorded during periods when tests were conducted in the upper bypass. Hourly counts of each race of salmonid captured in the sampling tank were recorded from 8 April to 17 April, 1 May to 13 May, and 18 May to 24 May 1992. Counts of wild and hatchery-reared fish were combined.

The numbers of juvenile salmonids moving downstream through the east-bank fish ladder at Three Mile Falls Dam were documented from 3 March to 15 June 1991 using video-taped recordings at the viewing window. Individual species could not be determined. Passage of juvenile salmonids through the east-bank fish ladder were compared with juvenile passage counts collected at the west-bank fish bypass in Spring 1991 (Hayes et al. 1992).

Westland Dam

Velocity

Approach and sweep water velocities were measured in front of all ten drum screens at the Westland Canal juvenile fish bypass facility at Westland Dam on 9 June and 10 June 1992. A Marsh McBirney (model 201 D) flow meter was used to record current velocities (fps) at 20%, 50%, and 80% of water depth. For recording sweep velocities, the probe was positioned parallel to the screen and pointing upstream; for recording approach velocities, on a perpendicular and away from the screen. Measurements were taken close to the drum screens along vertical transects at the center of the screen and between the centerline and upstream and downstream screen edges.

Trap Design

We visited the Westland Canal juvenile fish bypass facility at Westland Dam in the spring and summer of 1992 to develop site-specific fyke net designs for screen leakage evaluations scheduled for Spring 1993. For the design of drum screen and traveling screen fyke nets, we considered (1) the availability of structures for securing and deploying the nets, (2) maximum water height, (3) amount of net required to dissipate inflow and effectively capture fish, (4) effects on normal flow patterns through the screens, and (5) accessibility.

RESULTS

Three Mile Falls Dam

Injury

The WEID Canal juvenile fish bypass facility caused few injuries to juvenile salmonid test fish that traveled past the screens or through the headgates, downwell, bypass pipe, and outfall (Tables 2 and 3). Injury rates of treatment and control groups were not significantly different ($P > 0.10$) in any of the tests. Mean fork lengths of paired treatment and control test fish were similar within each test (Table 4).

In the upper bypass, summer steelhead, spring chinook and fall chinook salmon suffered few injuries moving through headgates set at reduced openings. Screen injuries to summer steelhead were low, day or night. Upper 95% confidence limits for the difference between treatment and control net weighted injury rates did not exceed 6.5% for any of the tests conducted in the upper bypass. Summer steelhead and spring chinook salmon were in poorer pre-test condition than fall chinook salmon. Negative net injury rates were more likely to be calculated for test groups that had relatively high levels of pre-test injury (Table 2). Few fish were observed with other types of injuries. The "other" injury category was comprised of nearly equal proportions of eye injuries, lesions, and bird marks.

In the lower bypass, non-standard operation of the bypass downwell (high pool depth) did not significantly decrease injury rates to spring chinook

Table 2. WEID Canal fish bypass facility headgate and screen injury tests: Mean damage percentages (fish partly descaled, descaled, otherwise injured, and dead); net weighted injury; mean injury rates and 95% confidence limits (treatment fish minus control fish), Three Mile Falls Dam, Umatilla River, Spring 1992 (pre-test values are in parentheses; N = number of test replicates).

						Mean percentaoe of fish recaptured					Treatment minus control				
Species[a]	Test[b]	Control or treatment	Time	Number released	Number recaptured	Partly Descaled	Descaled	Other	Mortality	Net weighted injury	Mean	95% Confidence limits LowerCL	UpperCL	Probability[c]	N
STS	HIT	Control	Day	636	443	31.0 (31.6)	0.6 (0.4)	0.4 (0.0)	0.0 (0.0)	0.1	-0.8	-6.1	4.5	p > 0.89	9
STS	HIT	Treatment	Day	626	325	28.4 (28.5)	0.0 (1.1)	0.2 (0.0)	0.0 (0.0)	-0.7					9
CHS	HIT	Control	Day	355	288	31.9 (45.5)	0.7 (1.1)	0.0 (0.0)	0.7 (0.0)	-4.1	1.5	-3.5	6.5	p > 0.30	9
CHS	HIT	Treatment	Day	356	265	42.4 (53.8)	1.2 (0.0)	0.0 (0.0)	0.4 (0.0)	-2.6					9
CHF	HIT	Control	Day	683	322	6.6 (5.3)	0.0 (0.0)	0.2 (0.0)	0.0 (0.0)	0.5	0.5	-1.8	2.7	p > 0.36	9
CHF	HIT	Treatment	Day	666	283	7.2 (6.7)	0.6 (0.0)	1.7 (0.4)	0.0 (0.0)	1.0					9
STS	SIT	Control	Day	642	563	36.8 (33.5)	0.7 (0.0)	0.0 (0.0)	0.0 (0.0)	1.6	-1.5	-5.9	2.3	p > 0.71	8
STS	SIT	Treatment	Day	636	443	31.0 (31.2)	0.6 (0.4)	0.4 (0.0)	0.0 (0.0)	0.1					9
STS	SIT	Control	Night	627	614	24.8 (14.5)	0.2 (0.4)	0.0 (0.0)	0.0 (0.0)	3.3	-2.0	-3.7	-0.3	p > 0.71	9
STS	SIT	Treatment	Night	638	475	28.3 (23.8)	0.0 (0.4)	0.6 (0.4)	0.0 (0.0)	1.3					9

a STS = summer steelhead; CHS = spring chinook salmon; CHF = fall chinook salmon.

b HIT = headgate injury test; SIT = screen injury test.

c Probability = 1 minus the probability that treatment - control > 0.

Table 3. WEID Canal fish bypass facility downwell and outfall injury tests: Mean damage percentages (fish partly descaled, descaled, otherwise injured, and dead); net weighted injury; mean injury rates and 95% confidence limits (treatment fish minus control fish), Three Mile Falls Dam, Umatilla River, Spring 1992 (pre-test values are in parentheses; N = number of test replicates).

						Mean percentage of fish recaptured					Treatment minus control				
Species[a]	Test[b]	Control or treatment	Flow[c] -pool depth	Number released	Number recaptured	Partly Descaled	Descaled	Other	Mortality	Net weighted injury	Mean	95% Confidence limits LowerCL	UpperCL	Probability[d]	N
CHS	DIT	Control	5-LP	401	88	44.5 (35.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	3.2	-2.2	-12.3	a.0	p > 0.62	6
CHS	DIT	Treatment	5-LP	406	135	35.1 (34.4)	1.2 (0.0)	0.0 (0.0)	0.0 (0.0)	1.0					6
CHS	DIT	Control	5-HP	379	120	27.4 (28.8)	0.0 (0.6)	0.0 (0.0)	0.0 (0.0)	-0.8	5.8	-3.9	15.5	p > 0.14	6
CHS	DIT	Treatment	5-HP	378	90	38.8 (23.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.0					6
CHS	DIT	Control	25-LP	415	200	28.4 (25.7)	51.7 (0.0)	0.0 (0.0)	10.1 (0.0)	46.3	-2.9	-7.4	1.5	p > 0.84	6
CHS	DIT	Treatment	25-LP	409	210	29.5 (16.5)	45.8 (0.0)	0.0 (0.0)	a.5 (0.0)	43.4					6
CHS	DIT	Control	25-HP	418	233	36.8 (10.6)	14.5 (0.0)	0.0 (0.0)	21.2 (0.0)	39.6	-5.2	-13.8	3.4	p > 0.64	6
CHS	DIT	Treatment	25-HP	414	251	34.1 (15.5)	18.0 (0.0)	0.0 (0.0)	16.2 (0.0)	34.4					6
CHF	OIT	Control	5-LP	346	323	70.9 (67.7)	2.0 (0.0)	0.0 (0.0)	3.4 (0.0)	5.8	7.3	-6.1	20.7	p > 0.16	9
CHF	OIT	Treatment	5-LP	354	137	59.4 (60.9)	12.4 (1.0)	0.0 (0.0)	6.0 (0.0)	13.1					9
CHF	OIT	Control	25-LP	419	383	51.3 (71.6)	13.5 (0.0)	0.0 (0.0)	28.8 (0.0)	31.0	8.1	-4.5	20.7	p > 0.12	9
CHF	OIT	Treatment	25-LP	402	374	41.9 (76.4)	15.7 (0.9)	0.0 (0.0)	40.8 (0.0)	39.1					9

[a] STS = summer steelhead; CHS = spring chinook salmon; CHF = fall chinook salmon.
[b] DIT = downwell injury test; OIT = outfall injury test.
[c] Bypass flow in cubic feet per second; downwell pool depths: LP = low pool, HP = high pool.
[d] Probability = 1 minus the probability that treatment - control > 0.

Table 4. Mean fork length (mm) and origin of test fish used in injury evaluations of the WEID Canal juvenile fish bypass facility, Three Mile Falls Dam, Umatilla River, Spring 1992.

Species[a]	Test[b]	Treatment or control	Mean fork length	Standard deviation	*n*	Origin
STS	HIT	Treatment	192.8	18.5	180	Umatilla Hatchery, OR
STS	HIT	Control	192.3	17.4	369	Umatilla Hatchery, OR
STS	SIT	Treatment	192.3	17.4	369	Umatilla Hatchery, OR
STS	SIT	Control	194.9	17.8	347	Umatilla Hatchery, OR
CHS	HIT	Treatment	133.6	7.1	90	Carson NFH, WA
CHS	HIT	Control	133.4	7.6	93	Carson NFH, WA
CHS	DIT	Treatment	130.1	7.9	242	Carson NFH, WA
CHS	DIT	Control	131.5	8.5	233	Carson NFH, WA
CHF	HIT	Treatment	85.6	5.9	253	Irrigon Hatchery, OR
CHF	HIT	Control	85.9	5.5	294	Irrigon Hatchery, OR
CHF	OIT	Treatment	90.0	6.2	120	River-run fish
CHF	OIT	Control	90.7	6.3	120	River-run fish
CHF fry	TSLT	--	64.5	4.7	296	Umatilla Hatchery, OR
CHF fry	TSIT	Treatment	70.7	4.1	43	Umatilla Hatchery, OR

a *STS = summer steelhead CHS = spring chinook salmon, CHF = fa77 chinook salmon*
b *HIT = headgate injury test, SIT = screen injury test, DIT = downwe injury test, OIT = outfa77 injury test, TSLT = traveling screen 7eakage test, TSIT = traveling screen impingement test.*

salmon, as compared to standard operation of the bypass downwell (low pool depth). The largest difference between treatment and control net weighted injury rates recorded during the downwell injury tests was 5.8%. For low and high pool tests conducted at a 5-cfs bypass flow, partial descaling accounted for almost all of the pre-test and post-test injury. In contrast, substantial numbers of post-test fish were recorded as descaled or dead for both low and high pool tests conducted at a 25-cfs bypass flow. The largest differences between treatment and control net weighted injury rates were recorded in the outfall injury tests (7.3% and 8.1%). Upper 95% confidence limits for the difference between treatment and control net weighted injury rates during outfall injury tests at both bypass flows tested was 20.7%. More than 60% of the fall chinook used in the outfall injury test were partially descaled prior to release.

Delayed Mortality

There was no indication that fish suffered delayed mortality as a result of travel through the upper or lower bypass. In the upper bypass, net delayed mortality rates of test fish were 0% or less (Table 5). However, delayed mortality rates for treatment and control groups varied from 0% for summer steelhead to approximately 13% for fall chinook salmon. Maximum water temperatures were $10^{\circ}F$ to $13^{\circ}F$ lower during delayed mortality tests with summer steelhead, as compared with temperatures during tests with spring and fall chinook salmon.

In the lower bypass, net delayed mortality for test fish did not exceed 13% (Table 5). However, delayed mortality for treatment and control groups were as high as 27% for spring chinook salmon after the downwell injury tests at a 25-cfs bypass flow and 96% for fall chinook salmon after the outfall injury test. fall chinook and spring chinook salmon were subjected to poor pre-test holding conditions and turbulent flow in the outfall trap.

Travel Time

Median travel time from downstream of the headgates to the sampling tank was not significantly different (X^2 = 0.70, P > 0.70) for all three species and consistently lower than their respective travel times when released above the headgates. In addition to the longer amount of time required to recapture test fish released upstream of the headgates, 5 of 9 replicate groups of fall chinook salmon and summer steelhead did not reach the 50% recapture mark by the end of the test period. All 9 groups of spring chinook salmon test groups released upstream of the headgates reached the 50% recapture mark and traveled to the sampling tank approximately 2.5 times faster than fall chinook salmon or summer steelhead (Table 6). However, this difference in median travel time among the three species of test fish released infront of the headgates was not statistically significant (X^2 = 2.42, P > 0.30). Almost all of the replicate groups of test fish released upstream and downstream of the headgates did not reach a 95% rate of recapture. The only groups that reached a 95% recapture rate were 2 of 9 spring chinook salmon groups released downstream of the headgates. Canal withdrawals were 40.5 cfs, 66.3 cfs, and 54.1 cfs during travel time evaluations in the upper bypass with spring chinook salmon, fall chinook salmon, and summer steelhead, respectively.

The percentage of summer steelhead recaptured within 4 hours of release downstream of the headgates was slightly higher at night (44%) than in the day (38%). However, this small difference was not statistically significant (Z = 1.16, P > 0.25).

Table 5. Percent mortality of test fish within 48 hours of recapture and maximum water temperatures (°F) during holding at the WEID Canal juvenile fish bypass facility, Three Mile Falls Dam, Umatilla River, Spring 1992.

Species[a]	Test[b]	Conditions[c]	*n*	48 hour mortality (%) Treatment	Control	Net	Maximum Water Temperature
STS	**HIT**	**Day**	244	0	0	0	56
CHS	**HIT**	**Day**	258	4	4	0	66 - 69
CHF	**HIT**	**Day**	423	12	13	-1	66 - 69
STS	**SIT**	**Day**	653	0	0	0	56
STS	SIT	**Night**	662	0	0	0	56
CHS	**DIT**	**LP @ 5 cfs**	**55**	**9**	**0**	**9**	57
CHS	DIT	**HP @ 5 cfs**	**89**	**10**	5	5	57
CHS	DIT	**LP @ 25 cfs**	**30**	2:	27	-20	61 - 65
CHS	DIT	**HP @ 25 cfs**	**56**		25	-4	61 - 65
CHF	**OIT**	**LP @ 5 cfs**	**290**	**96**	91	5	69 - 71
CHF	**OIT**	**LP @ 25 cfs**	345	91	78	13	69 - 71

a STS = summer steelhead CHS = spring chinook salmon CHF = fa77 chinook salmon
b HIT = headgate injury test, SIT = screen injury test, DIT = downwell injury test, OIT = outfa77 injury test.
c LP = low (downwe77) pool depth, HP = high (downwe77) pool depth, @ 5 cfs / @ 25 cfs = at a bypass flow of 5 cfs or 25 cfs.

In **the lower bypass, high** downwell **pool depth led to slightly higher recovery rates of spring chinook salmon at half-hour sampling intervals and 25-cfs bypass flows (Table 6). However, this difference was not statistically significant (T = 1.37, P > 0.15). The highest recapture rate** (91.8%) was **recorded for fall chinook salmon traveling from the start of the bypass pipe to the outfall trap at a 25-cfs bypass flow with a standard (low) downwell pool depth. This was significantly higher than the recapture rates for spring chinook salmon recorded under the same conditions, both after sampling intervals of half an hour (39.0%, T =** 9.01, **P < 0.001) and one hour (57.1%, T** = 5.53, **P** < 0.001). **After one-hour sampling in both cases, mean recovery rates of spring chinook salmon were 2.5 times greater at a bypass flow of 25 cfs, as compared to 5 cfs (T = 4.71, P** < 0.001).

Table 6. Median travel time determined as the number of hours to recapture 50 percent of test fish released in the upper bypass and the percentage of test fish recaptured after one-hour or half-hour sampling intervals in the lower bypass at the WEID Canal juvenile fish bypass facility, Three Mile Falls Dam, Umatilla River, Spring 1992.

Species	Bypass section	Sampling inter-val	Downwell pool depth[a]	Bypass flow (cfs)	Release site[b]	Capture site[c]	Median travel time	Stnd. dev.	N	Mean Recapture (%)	Stnd. dev.	N
CHS	Upper			5	U-H	ST	13.1	8.3	9	74.3	10.1	9
CHF	Upper	--		5	U-H	ST	32.3	22.8	4	55.3	25.7	9
STS	Upper	--		5	U-H	ST	33.5	25.7	4	42.5	16.1	9
CHS	Upper	--		5	D-H	ST	11.1	12.4	9	81.1	11.2	9
CHF	Upper	--		5	D-H	ST	9.0	8.3	4	69.7	12.4	9
STS	Upper	--		5	D-H	ST	10.3	10.3	4	47.1	23.4	9
CHS	Lower	1 hr	LP	5	BCW	OT	--		--	32.6	25.8	6
CHS	Lower	1 hr	HP	5	BCW	OT			--	22.6	19.9	6
CHS	Lower	1 hr	LP	25	BCW	OT			--	61.0	14.9	3
CHS	Lower	1/2 hr	LP	25	BCW	OT	--	--	--	42.3	17.3	6
CHS	Lower	1/2 hr	HP	25	BCW	OT	--	--		58.4	20.5	6
CHF	Lower	1 hr	LP	5	BP	OT	--	--	--	33.8	13.9	6
CHS	Lower	1 hr	LP	5	BP	OT	--	--		22.2	19.3	6
CHS	Lower	1 hr	HP	5	BP	OT	--	--	--	28.8	16.4	6
CHS	Lower	1 hr	LP	25	BP	OT	--	--		57.1	11.1	3
CHF	Lower	1/2 hr	LP	25	BP	OT				91.8	7.8	6
CHS	Lower	1/2 hr	LP	25	BP	OT	--	--	--	39.0	9.4	3
CHS	Lower	1/2 hr	HP	25	BP	OT	--	--	--	51.0	20.4	6

[a] *LP = low pool, HP = high pool.*
[b] *U-H = upstream of headgates, D-H = downstream of headgates, BCW = bypass channel weir, BP = bypass pipe.*
[c] *ST = sampling tank, OT = outfa77 trap.*

Diversion Rate

Of the three test species released upstream of the headgates, a significantly higher percentage of spring chinook salmon were diverted into the bypass than summer steelhead or fall chinook salmon ($X^2 = 11.3$, $P < 0.004$, Table 6).

Mean recovery rates were higher for test fish released downstream of the headgates than for those released upstream of the headgates (Table 6). The difference in mean recovery rates between test fish released upstream and downstream of the headgates was 14.4%, 6.7% and 4.6% for summer steelhead, spring chinook salmon and fall chinook salmon, respectively.

Traveling Screen Leakage and Impingement

Fall chinook salmon fry leakage through, and impingement on, the traveling screen was less than 1% for the pumpback bay operations tested (Table 7). At least 83% of released test fry were recaptured during the traveling screen leakage test. On the impingement test, 64% were recaptured. Capture efficiency of the fyke net at the terminus of the river-return pipe was 97% or higher. Mean fork lengths of fall chinook fry used in the traveling screen leakage (64.5 mm) and traveling screen impingement (70.7 mm) tests were transitional between fry and fingerling (Table 4).

Velocity

Evacuation of water from the pumpback bay at river-return drain pipe openings of 20%, 30%, and 40% generally produced higher sweep velocities across the face of the traveling screen than operating canal pumps singularly or in tandem (Table 8). During all pumpback bay operations, the lowest approach velocities were measured along the downstream transects. At each drain pipe opening tested, irregular patterns of approach velocity were produced. Approach velocities exceeded 0.5 fps in at least one sampling location during all pumpback bay operations tested. Operating the canal pumps singly or the drain pipe at a 20% opening produced the lowest overall approach velocities. However, sweep velocities across the traveling screen were on average more than 50% lower when operating the canal pumps singly (0.51 fps) than when the drain pipe was open 20% (1.10 fps). Operating canal pump #2 resulted in a more uniform pattern of water intake through the traveling screen than operating canal pump #l.

In comparison to standard operations with both canal pumps on, current velocities at the entrance to the bypass channel decreased by an average of 42% when operating the canal pumps singly, but were slightly higher (3%) when the drain pipe was 20% open. Excessive (>2.0 fps) bypass channel velocities were recorded when the drain pipe was 30% open.

Table 7. Fall chinook salmon fry leakage through the traveling screen during tests conducted at varying river-return drain pipe openings. Impingement on the traveling screen during tests with both canal pumps operating at the WEID Canal juvenile fish bypass facility, Three Mile Falls Dam, Umatilla River, April 1992.

Travelins Screen Leakage

Date	No. of fry released	No. of fry recaptured	Fyke net efficiency	Leakage (% of fry)	Pipe opening
04/14/92	400	398	100 %	0.500	20 %
04/15/92	400	334	97 %	0.003	30 %
04/16/92	400	333	97 %	0.003	40 %

Travelinq Screen Impinsement

Date	No. of fry released	No. of fry recaptured	Impingement (% of fry)
05/06/92	400	257	0.008

River-run Juvenile Salmonid Passage

Fish were trapped at the Westland Canal juvenile fish bypass facility, 24 river miles upstream of the WEID Canal fish bypass, and released near the mouth of the Umatilla River from 1 April to 22 May 1992. There were two exceptions: (1) from 13 April to 27 April, 2,500 lb of fish were released below Westland Dam when river flow was adequate, and (2) two periods in May when fish spilled over the dam. A rapid increase in smolt passage at the WEID Canal fish bypass was documented on 14 April and 19 May (Figure 4).

A minimum of 150,000 juvenile salmonids passed downstream through the east-bank ladder facility at Three Mile Falls Dam from 4 March to 27 June 1991. Power outages and removal of the video camera from the viewing window during a flood in May resulted in 10.3 days of missing data. Downstream passage of smolts through the adult ladder peaked from 18 April to 18 May (Figure 5). Juvenile salmonid counts at the ladder declined sharply after a large flood event in the third week of May. Numbers of smolts moving through the ladder did not appear to be related to river flow.

Table 8. Sweep and approach velocity measurements (in fps) taken at the traveling screen and bypass channel entrance at the WEID Canal juvenile fish bypass facility, Three Mile Falls Dam, Umatilla River, April 1992. Velocities were measured at varying water depths, transects, and operating conditions.

Sampling location[a]	Operating condition[b]	Sweep velocity Percent of water depth 20%	50%	80%	Approach velocity Percent of water depth 20%	50%	80%
TS-U	RRP-20% open	1.30	1.50	1.30	0.25	0.35	0.53
TS-U	RRP-30% open	1.10	1.70	1.80	0.30	0.10	0.65
TS-U	RRP-40% open	2.13	2.80	2.05	-0.28	-0.68	0.70
TS-U	CP-1t2 on	0.87	1.15	0.92	0.82	0.98	1.03
TS-U	CP-1 on	0.35	0.78	0.55	0.51	0.47	0.63
TS-U	CP-2 on	0.64	0.63	0.60	0.43	0.42	0.55
TS-M	RRP-20% open	1.25	1.20	1.00	0.15	0.40	0.30
TS-M	RRP-30% open	1.40	1.50	1.20	0.80	0.37	0.50
TS-M	RRP-40% open	1.95	2.40	1.78	0.35	0.40	1.10
TS-M	CP-1t2 on	0.70	1.12	0.90	0.73	0.59	0.59
TS-M	CP-1 on	0.51	0.49	0.48	0.35	0.30	0.30
TS-M	CP-2 on	0.63	0.58	0.40	0.44	0.33	0.30
TS-D	RRP-20% open	1.15	0.85	0.35	0.35	0.30	0.05
TS-D	RRP-30% open	1.10	1.05	0.80	0.70	0.05	0.20
TS-D	RRP-40% open	1.16	1.71	1.20	0.57	0.30	0.40
TS-D	CP-lt2 on	0.61	0.53	0.40	0.09	0.01	0.03
TS-D	CP-1 on	0.50	0.43	0.34	0.21	0.12	0.22
TS-D	CP-2 on	0.38	0.52	0.35	0.34	0.22	0.24
BC-M	RRPtCP-OFF @ 5 cfs				0.32	0.33	0.40
BC-M	RRPtCP-OFF @ 25 cfs				1.93	2.05	2.30
BC-M	RRP-20% open				1.67	1.75	1.93
BC-M	RRP-30% open				2.32	2.43	2.50
BC-M	RRP-40% open				2.83	2.92	3.05
BC-M	CP-lt2 on				1.55	1.70	2.01
BC-M	CP-1 on				0.93	1.04	0.99
BC-M	CP-2 on				0.97	1.07	1.15

[a] *TS-U = upstream edge of traveling screen, TS-M = midsection of traveling screen, TS-D = downstream edge of traveling screen, BC-M = midsection of bypass channel entrance.*

[b] *RRP = river return pipe, CP = canal pump.*

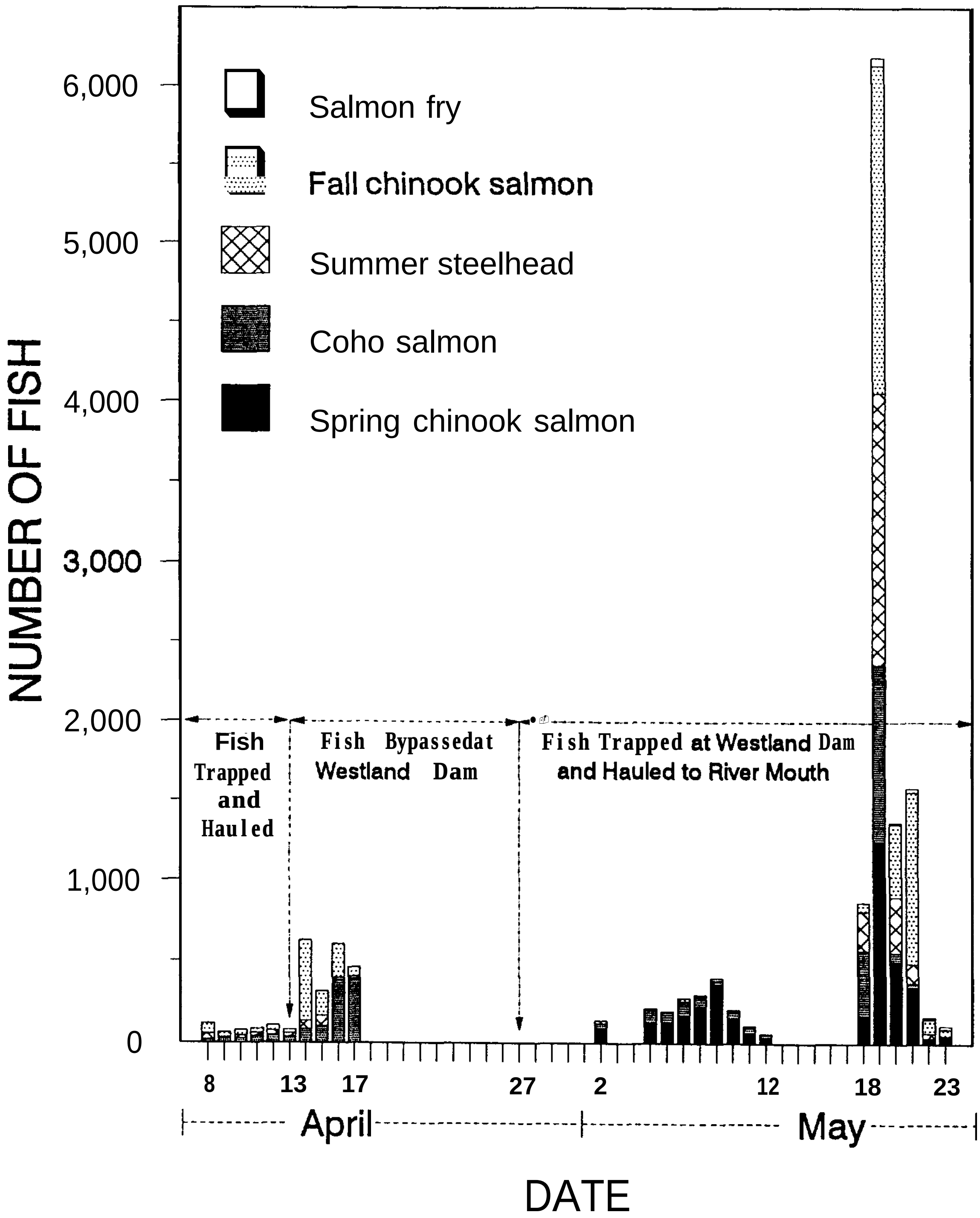


Figure 4. Number of river-run juvenile salmonids passing through the fish bypass facility at Three Mile Falls Dam, Umatilla River on 8 April - 17 April, 2 May, 5 May - 12 May and 18 May - 23 May 1992.

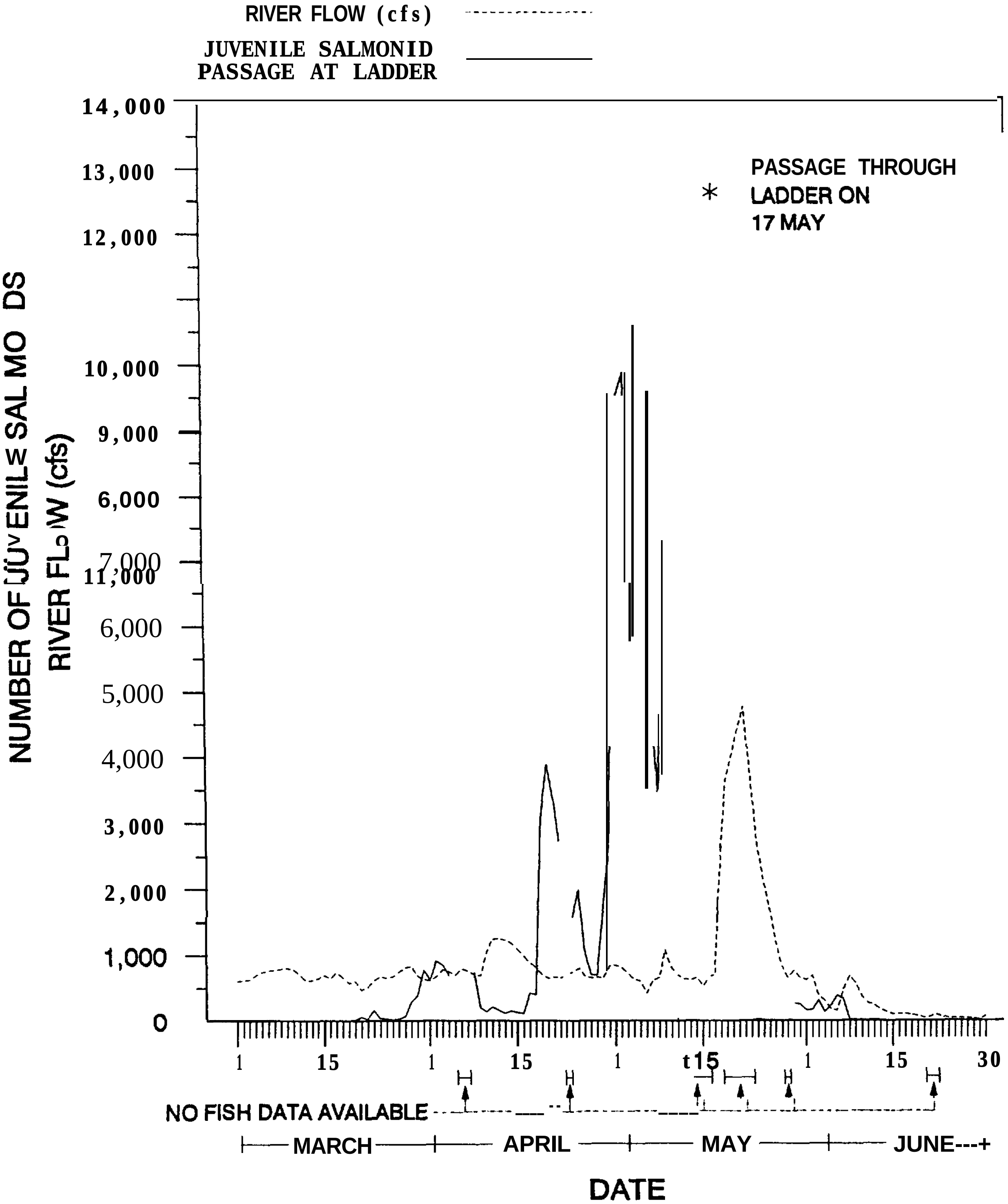


Figure 5. Video tape counts of river-run juvenile salmonids passing downstream through the east-bank adult fish ladder at Three Mile Falls Dam, Umatilla River on 4 March - 27 June 1991.

Approximately twice as many juvenile salmonids passed downstream through the adult ladder (74,131) than through the juvenile bypass (38,996) at Three Mile Falls Dam from 23 April to 9 May 1991 (Figure 6). In late April, fish passage rates were higher through the fish bypass than the ladder but this pattern was reversed from 29 April to 8 May. Greater use of the adult ladder by smolts relative to the fish bypass did not appear to be related to canal or river flows.

Westland Dam

Velocity

Sweep velocities across the face of drum screens #1 through #7 were close to or above 1 fps (Table 9). Sweep velocities were lowest at drum screens #8 through #10 and at 80% of water depth at all ten drum screens. Approach velocity measurements indicate an uneven pattern of flow occurs through the drum screens. Approach velocities were greatest at 80% of water depth and low or negative at 20% and 50% of water depth.

Approach velocities in front of the drum screens exceeded 0.5 fps at only 2 of 90 locations sampled. Both these locations were at 80% water depth on the upstream transects of drum screens #7 and #9. Sweep velocities exceeded approach velocities in all sampling locations.

Trap Design

Fyke net designs have been developed for drum and traveling screen leakage tests scheduled for Spring 1993 at Westland Canal. Walkway supports behind the drum screens created obstructions that precluded use of a single fyke net behind each screen. As a result, two fyke nets will be placed behind each drum screen in the Westland Canal (Figure 7). The nets will be made of 3/16-inch knotless nylon netting attached to an angle iron frame measuring approximately 6-feet wide x 7-feet high at the mouth. Each fyke net will be approximately 4 or 6.5-feet deep and terminate with a 1-foot x 1.5-foot cod end. Two styles of fyke nets varying in their angle and depth of taper will be used to compensate for expected flow patterns behind the drum screens, with the shorter design used behind drum screens #1 through #6 and the longer style behind screens #7 through #10. The X-beam walkway supports will provide guides for the angle iron fyke net frames. Plywood dividers will be secured between the cement screen structure and walkway supports to prevent fish movement between nets.

We will also use fyke nets to test for leakage through the traveling screen in the Westland Canal juvenile fish bypass. These nets will be made of 3/16-inch knotless nylon netting and taper from a diameter of 2 feet to 1 foot over a length of 14 feet (Figure 8). The mouth of the net will be secured to an aluminium orifice plate placed behind the existing traveling screen orifice plate. The dimensions of the orifice that will hold the net are wider than the dimensions of the existing orifice, thus minimizing any potential effects on facility operation. Ropes secured to grommets on the hoop frames will stabilize the submerged portion of the fyke net in the pumpback bay water currents.

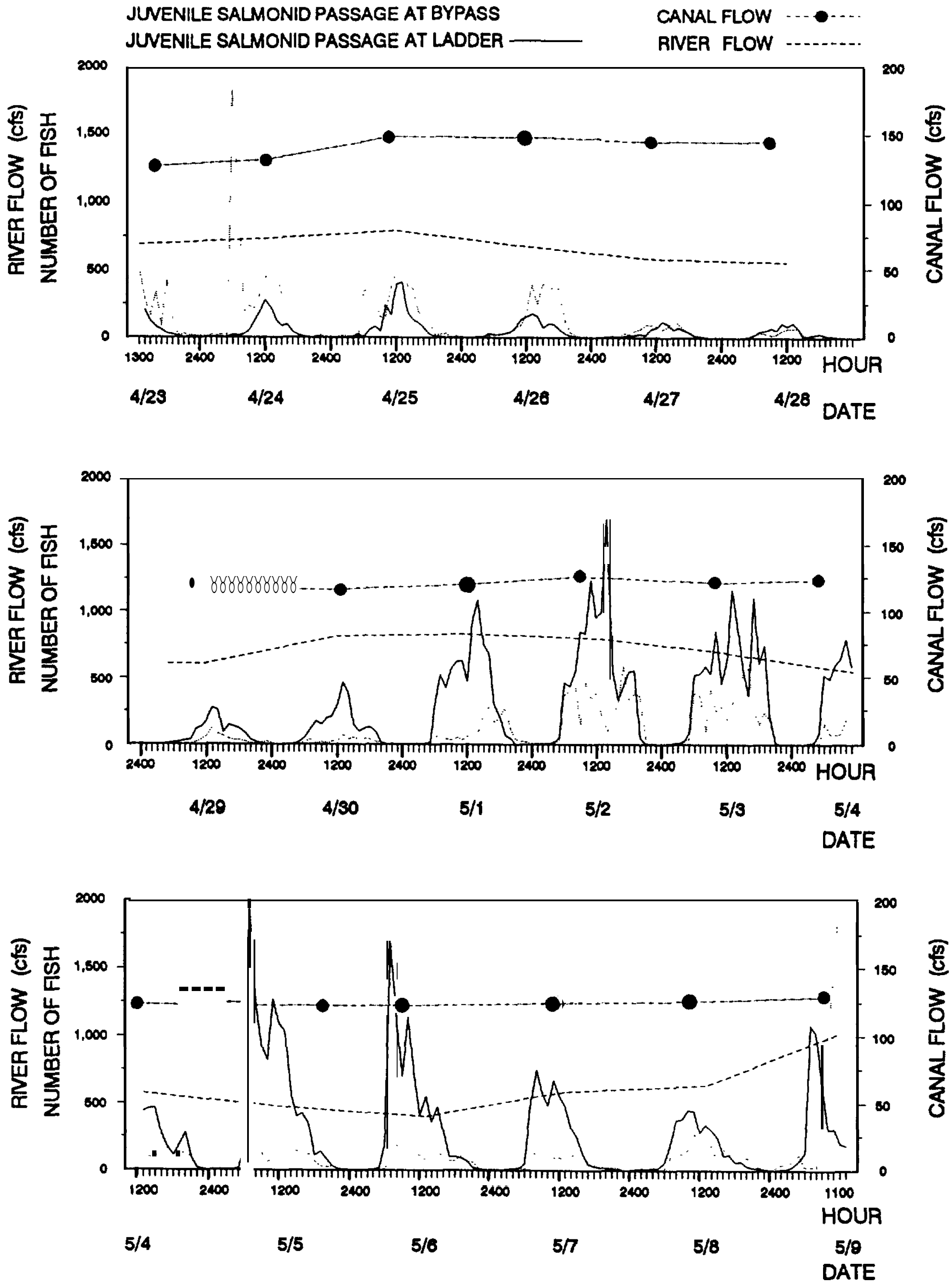


Figure 6. Number of river-run juvenile salmonids passing through the juvenile fish bypass and adult ladder facilities at Three Mile Falls Dam, and flow (cfs) at the WEID Canal and Umatilla River near Umatilla, Oregon on 23 April - 9 May 1991.

Table 9. Sweep and approach velocities (fps) at the Westland Canal drum screens, Umatilla River, Spring 1992. Canal flow was 137 to 167 cfs.

Drum screen no.	Transect	Sweep velocity Percent of water depth 20%	50%	80%	Approach velocity Percent of water depth 20%	50%	80%
1	Upstream	.70	.92	.70	.15	.02	.46
2	Upstream	1.12	1.22	1.02	-.09	-.08	.09
3	Upstream	1.20	1.15	1.03	-.16	-.25	.22
4	Upstream	1.13	1.26	1.00	-.05	-.23	.20
5	Upstream	1.21	1.10	1.05	.05	.00	.25
6	Upstream	1.20	1.07	.80	-.08	-.25	.27
7	Upstream	1.03	1.05	.70	-.11	-.17	.65
8	Upstream	1.04	1.00	.90	-.07	-.05	.30
9	Upstream	.85	1.05	.85	.00	-.02	.65
10	Upstream	.95	.90	.80	.03	.17	.45
1	Middle	1.10	.90	.87	-.13	-.05	.27
2	Middle	1.13	1.07	.95	-.33	-.43	.23
3	Middle	1.01	1.21	.98	-.10	-.15	.05
4	Middle	1.14	1.15	.90	-.26	.08	.24
5	Middle	.97	1.13	.88	-.02	-.35	.30
6	Middle	1.10	1.09	1.00	-.10	.17	.22
7	Middle	.93	.80	.73	-.11	-.12	.20
8	Middle	.84	.94	.77	-.11	-.22	.35
9	Middle	.90	.97	.79	-.04	-.04	.25
10	Middle	.95	.88	.60	-.13	-.14	.30
1	Downstream	1.14	1.08	.70	-.28	-.29	.20
2	Downstream	1.24	1.04	.93	-.29	-.35	.45
3	Downstream	1.16	1.00	.98	-.28	-.20	-.08
4	Downstream	1.01	1.13	1.03	-.23	-.16	.30
5	Downstream	.92	1.21	.90	-.08	.02	.06
6	Downstream	.93	1.06	.95	-.21	-.29	.13
7	Downstream	1.01	1.02	.75	-.09	-.26	.15
8	Downstream	.85	.87	.70	-.01	-.15	.15
9	Downstream	.98	.90	.70	-.11	-.17	.38
10	Downstream	1.05	.85	.65	-.08	-.02	.10

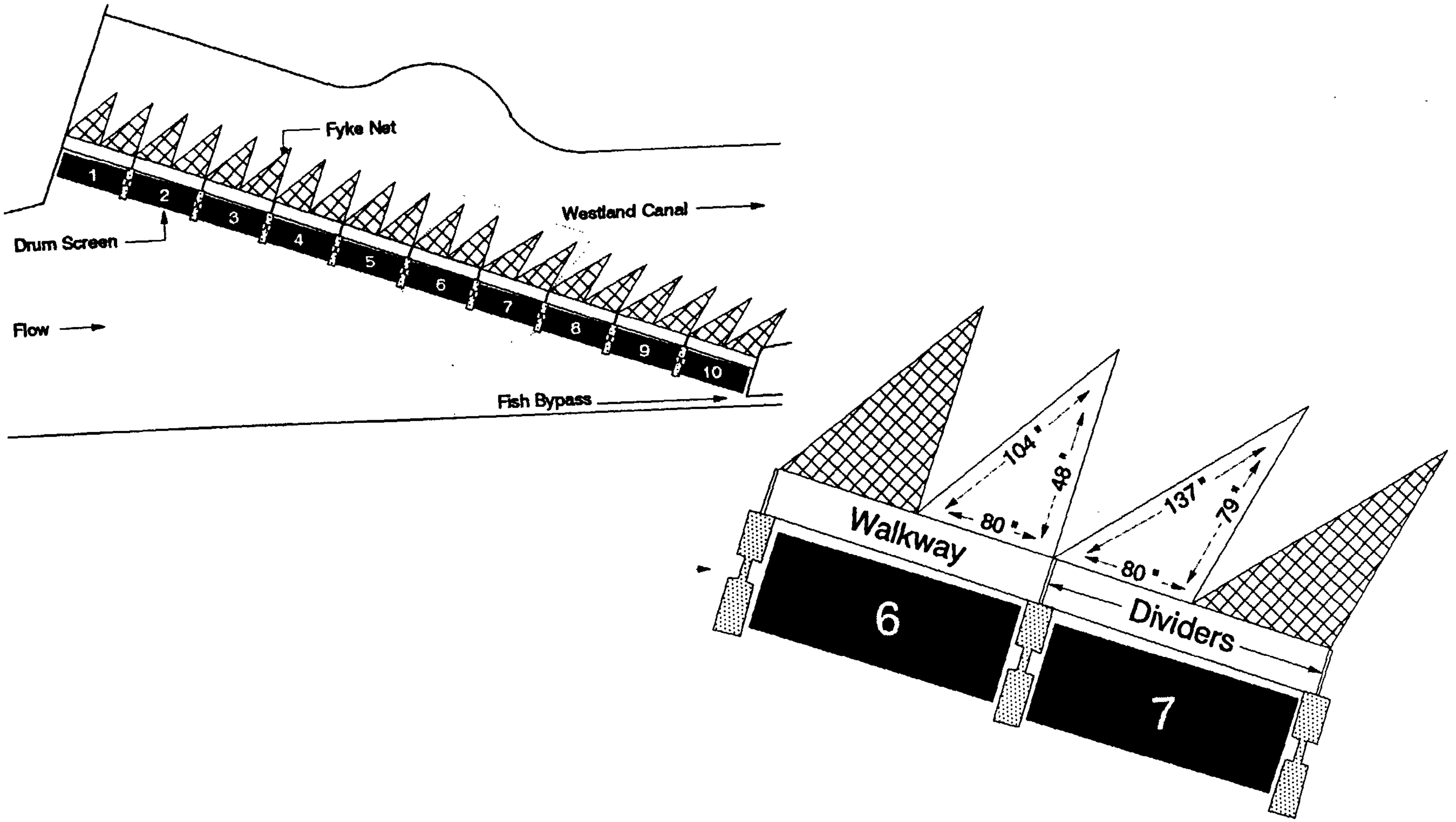


Figure 7. Fyke nets for drum screen leakage test at the Westland Canal juvenile bypass facility at Westland Dam, Umatilla River, Spring 1993.

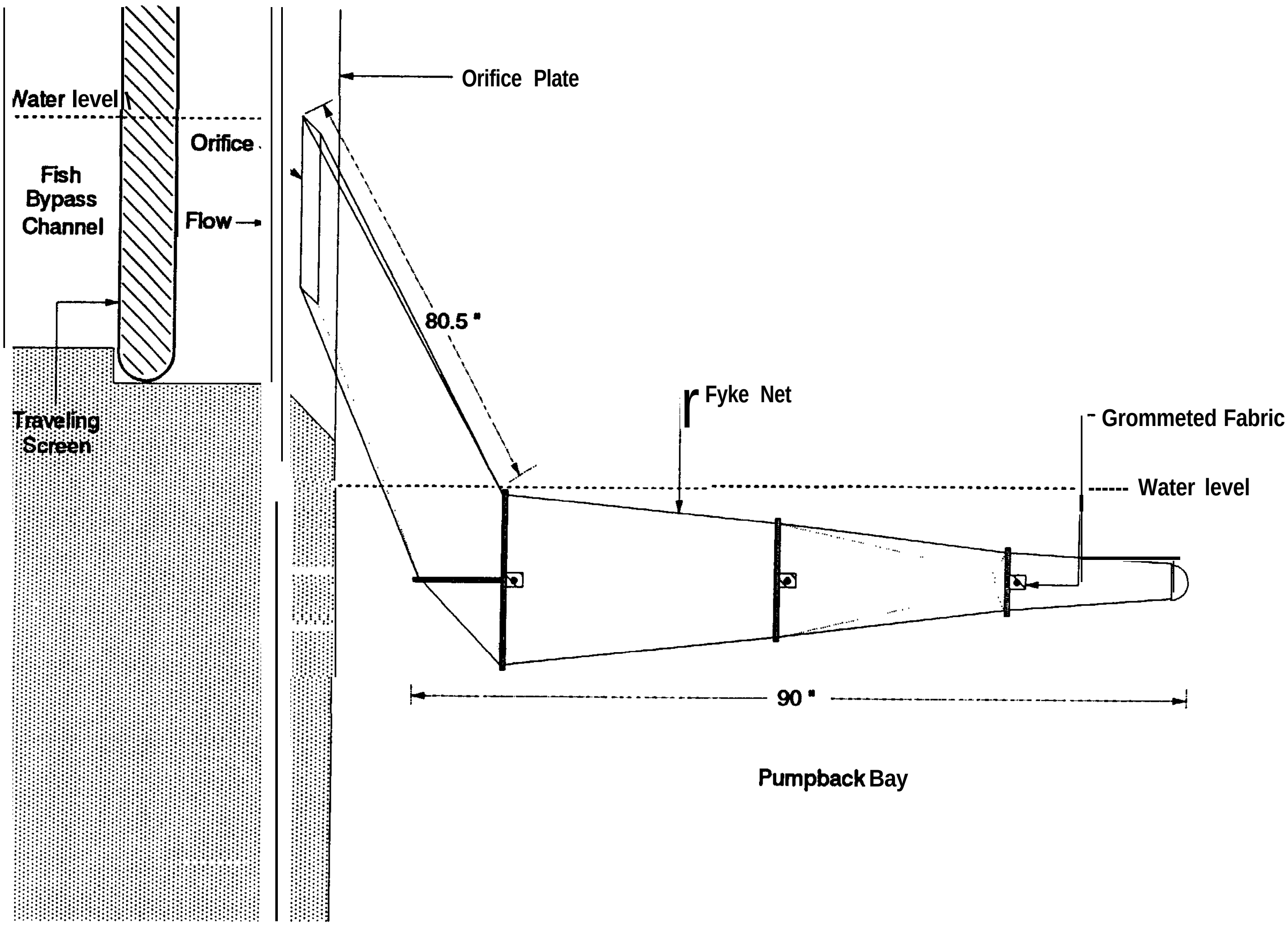


Figure 8. Fyke net for traveling screen leakage test at the Westland Canal juvenile bypass facility at Westland Dam, Umatilla River, Spring 1993.

DISCUSSION

Three Mile Falls Dam

Injury

Based on our tests at Three Mile Falls Dam and a review of other studies evaluating anadromous fish passage facilities in Northwestern rivers, it is unlikely that any significant injury of fish in the lower Umatilla River can be attributed to the WEID Canal juvenile fish bypass facility. Low injury rates encountered by test fish traveling past the screens and through the bypass downwell, pipe, and outfall are consistent with results of analogous tests at juvenile fish passage facilities in the Yakima. River Basin, Washington (Hosey & Associates 1988a, 1988b, 1989, 1990, Neitzel et al. 1985, 1987, 1988, 1990a, 1990b). In addition, low injury rates were recorded at the WEID Canal fish bypass in 1992 for test fish that passed through reduced headgate openings (33% and 66% open) and a deeper downwell pool depth.

Our study design to detect facility-caused injury assumed that treatment fish would receive a greater amount of injury than control fish. However, injury rates were higher for control fish than treatment fish in about half the tests. During similar evaluations of juvenile fish bypasses in the Yakima River Basin, control fish released into inclined screen traps received higher amounts of injury than treatment fish that entered the trap on their own volition (Hosey & Associates 1988, 1990). Hosey & Associates (1988) also observed that injury rates of test fish released close to the drum screens had higher injury rates than those released further upstream in the headworks. They hypothesized that test fish were disoriented immediately after release; those released next to the drum screens were more vulnerable to injury. Injury related to disorientation could explain why control fish released into the sampling tank during the screen injury (day) test received a slightly higher amount of injury than treatment fish. Unusually low pre-test injury for control fish in the screen injury (night) test appears to be the reason that a relative high net weighted injury rate was calculated for this group of control fish.

Regardless of biased estimates of pre-test condition and the possibility that control fish released in the sampling tank might have received more injury than treatment fish, test results indicated that injury rates to both treatment and control fish were very low in the upper bypass.

Facility-caused injury rates were low in tests conducted in the lower bypass as well. Fall chinook salmon received few injuries during the outfall injury tests at a 5-cfs bypass flow, but injury rates were higher at a 25-cfs bypass flow. Turbulent conditions in the outfall trap appeared to be the primary reason. The types of injuries recorded in the outfall injury test were more severe in 1992 than in 1991, when descaled and dead fish accounted for only a small percentage of the total injury. The higher level of injury in 1992 can probably be attributed to the inability to properly deploy the outfall trap during low river flows in 1992. In both 1991 and 1992, the exposure of test fish to high water temperatures, poor holding conditions, and diseases prior to release probably increased their predisposition to injury.

Similarly, in the downwell injury test, both treatment and control groups of spring chinook salmon suffered little injury at a S-cfs flow but high levels of injury at a 25-cfs flow, as a result of turbulent conditions in the outfall trap, coupled with a weakened pre-test condition. In addition, during high pool tests at a 25-cfs bypass flow, treatment and control fish were subjected to the additional stress of passing through a restricted opening at the lower bypass gate.

Delayed Mortality

Results of delayed mortality tests did not reflect detrimental effects associated with passage through various portions of the WEID Canal fish bypass facility at standard operation. High rates of delayed mortality observed were probably the result of disease, handling, the rigors of testing, and prolonged and poor holding conditions. Summer steelhead that were held for the least amount of time prior to release (6 days) in cool water and placed in large tanks suffered no delayed mortality during the test period. Conversely, spring chinook salmon suffered a low delayed mortality rate when they were held for 13 to 20 days prior to release and confined in small containers during delayed mortality tests. River-run spring chinook salmon collected from the sampling tank and held for 36 hours suffered less delayed mortality than spring chinook salmon test fish. In addition, symptoms of bacterial kidney disease were more prevalent on the spring chinook salmon test fish compared with the river-run spring chinook salmon. Stress caused by the restricted opening at the lower bypass gate and turbulence in the outfall trap aggravated delayed mortality in the downwell injury tests at a 25-cfs bypass flow.

Handling, warm water temperatures, and bacterial disease were the most probable causes for high delayed mortality rates for treatment and control fall chinook salmon after the outfall injury tests. Weakened condition of test fish was evident when fish died at a rate of 20% to 50% per day prior to the last two days of releases.

Travel Time

Numerous variables probably influence fish movement through a bypass facility, including smolting stage, size of fish, species-specific behaviors, local flow conditions, and the individual chacteristics of the facility. However, with the increasing amount of information on fish movements through fish bypass facilities, some general patterns are starting to emerge. The most consistent pattern during spring smolt migration is the difference in travel times between salmonid species. In the Yakima River system, juvenile chinook salmon travel past the screens and through river-return systems faster than steelhead. (Hosey and Associates 1988a, 1988b, 1989, 1990, Neitzel et al. 1985, 1990a, 1990b, 1991). Our studies in 1991 and 1992 corroborate these findings. However, median travel time of juvenile chinook salmon past the screens at the WEID Canal fish bypass was 2 hours to 10 hours <u>slower</u> than at fish bypass facilities in the Yakima River system with canal flows that exceed 1,000 cfs (Hosey and Associates 1988a, 1989, 1990. Neitzel et al. 1991). Slow travel through the WEID Canal screening facility is probably an effect of relatively low canal flows (37-150 cfs). This was especially true during drought conditions in 1992 (37-76 cfs canal flow). Movement of summer steelhead does not appear to be slowed by the screening facility at Three Mile Falls Dam. In 1992, mean travel times for summer steelhead through the WEID Canal screen facility (10 hours) were faster than many reported for steelhead at fish bypass facilities with canal flows that exceeded 1,000 cfs in the Yakima River system. However in 1991, summer steelhead test fish moved about three times slower than in 1992. The 1991 fish were on average about 20 mm smaller and in an earlier smolting stage than the 1992 test fish (Appendix A, Hayes et al. 1992).

High recovery rates from test fish releases in the upper bypass in 1991 and 1992 were only observed for spring chinook salmon. Percent recovery for upper bypass releases of fall chinook salmon and summer steelhead test fish was poorer, varying from 45% to 70% over this two year period. In addition, many replicate groups of fall chinook salmon and summer steelhead released in the upper bypass never reached the 50% recovery mark during the 96 hour test period. These observations suggest that (1) the physical conditions in the bypass facility may have been inadequate to encourage fall chinook salmon and summer steelhead to move through the upper bypass, or (2) that the test fish may not have been physiologically ready to begin downstream migration at their time of release. Information collected during future evaluations of upstream fish bypass facilities will help to discern whether the low recovery rates of fall chinook salmon and summer steelhead are facility-related or a behavioral response associated with smoltification.

Recovery rates of test fish passing through the bypass downwell, pipe, and outfall at Three Mile Falls Dam in 1992 were consistent with the results of tests conducted in 1991. The main trend observed during both years was an increase in recovery with higher bypass flow and smaller fish size. At a 25-cfs bypass flow, most fish species do not hold in the outfall pool for extended periods of time. The operating guidelines at Three Mile Falls Dam (USBR 1989) requiring a 25-cfs bypass flow appear to be validated.

Diversion Rate

Our test results probably underestimate normal diversion rates, since drought conditions in 1992 decreased canal withdrawals to approximately 30% to 50% of normal flow. In addition, actual fish diversion rates are somewhat higher than those calculated from 96 hours of sampling because we continued to capture test fish in early June that were released in early April.

The difference in recapture rates between releases made upstream of the headgates and downstream of the headgates was more pronounced for summer steelhead. Although only 55% of the summer steelhead released upstream of the headgates were diverted into the fish bypass, approximately 70% were recaptured from releases made below the headgates. Fall chinook salmon maintained the lowest recapture rates and spring chinook salmon maintained the highest recapture rates from both release locations. The trend exhibited for summer steelhead and spring chinook salmon is consistent with observations of recovery rates for these same species on the Yakima River system (Hosey and Associates 1988a, 1988b, 1990, Neitzel et al. 1990, 1991).

Traveling Screen Leakage and Impingement

Fall chinook salmon fry leakage through the traveling screen was less than 1% during all pumpback bay operations tested, which indicates that the seals around the traveling screen are very effective at preventing fry from entering the pumpback bay.

Traveling screen impingement tests with fall chinook fry will be continued in 1993. We were not able to successfully complete the full complement of tests in 1992. Observations made in 1991 of fall chinook salmon fry and subyearling impingement on the traveling screen (Hayes et al. 1992) emphasize the need to conduct these tests.

Velocity

In addition to biological testing, we measured the velocity of the current approaching and sweeping past the face of the traveling screen to evaluate the potential for fish impingement and leakage. Fisheries agencies have recommended that approach velocities not exceed 0.5 fps and sweep velocities be equal to or greater than approach velocities at the face of screens to protect juvenile salmonids from impingement and quickly guide them through the-bypass (Pearce and Lee 1991). Current velocities measured in front of the traveling screen during six different modes of pumpback bay operation suggested that running one canal pump or opening the drain pipe 20% are the preferred pumpback bay operations for meeting these criteria. In these two modes of operation, almost all approach velocity measurements were near or lower than 0.5 fps. In addition, sweep velocities exceeded approach velocities at the majority of sampling locations.

Although operating the pumpback bay with the drain pipe 20% open resulted in a better combination of approach and sweep velocities than operating either canal pump singly, this operational mode is only possible when water does not need to be returned to the canal. When water needs to be returned to the canal via one pump, operating pump #2 will produce better flow patterns than pump #l. Although single pump operations lower the frequency of fish impingement on the traveling screen, current velocities at the bypass channel entrance are reduced by approximately 40% compared with operation of both pumps in tandem. If a single-pump operation fails to provide sufficient current velocity at the bypass entrance to draw fish into the channel, installation of baffle boards behind the traveling screen might correct high approach velocities during two-pump operations. For fish passage, optimal flow and operation is a full 25-cfs bypass flow.

Uniform flow through the traveling screen is an important component of maintaining an efficient balance between sweep and approach velocities and for preventing fish impingement. Operating the canal pumps either singly or in tandem resulted in greater discharge of water through the upstream portion of the traveling screen. Operating the canal pumps singly substantially reduced the absolute magnitudes and differential of approach velocities across the face of the traveling screen.

Canal pump #2 appears to produce more uniform approach velocities because its intake is located closer to the downstream edge of the traveling screen than the intake of pump #1. In terms of future fish bypass designs, this suggests that greater uniformity in discharge through the traveling screen might be achieved by prudent placement of pump intakes.

River-run Juvenile Salmonid Passage

The sharp increase in juvenile fish passage at the WEID Canal juvenile fish bypass in early April may have been the result of a change to a bypass mode at Westland Dam 24 hours prior to this time. If so, this suggests that smolts can travel through this 24-mile section of river in one day. Alternatively, the increased river flow occurring at this time could stimulate the downstream movement of smolts holding in the river between Westland and Three Mile Falls dams.

Salmonid smolts migrating past Three Mile Falls Dam use the following routes: (1) the ladder and attractant portions of the adult fish passage facilities, (2) the juvenile fish bypass facility, and (3) spilling over the dam. Our evaluation of simultaneous smolt usage of the east-bank ladder and juvenile fish bypass facility in Spring 1991 indicated that the adult ladder is used extensively by smolts for downstream passage even when the bypass is operational. Smolts used the ladder for downstream migration to an even higher degree in relation to the juvenile fish bypass in the later half of the sampling period when smaller-sized fish (probably subyearling fall chinook salmon) dominated the video counts. The high amount of smolt passage through the ladder provides perspective on the importance of the ladder injury tests we plan to conduct in 1993.

1993 Tests

Traveling screen impingement tests were not conducted for all modes of pumpback bay operations in 1992. We will conduct these tests in 1993 to ensure that the potential for impingement is adequately evaluated.

Negative net injury rates were a problem that occurred in 1991 and 1992. Larger pre-test subsamples did not eliminate negative injury rates. Poor pre-test condition of test fish was another contributing factor. Pre-test condition of fish can probably be improved in 1993 by improving the holding conditions and shortening holding time.

Operational Problems at Three Nile Falls Dam

Trapping Equipment

An alternative method for deploying the inclined screen in the bypass channel circumvented problems we experienced in 1991. After positioning the fish separator in the bypass channel, a piece of 4 inch x 4 inch lumber was placed across the bypass channel to provide support for the upstream end of the inclined screen. The screen was then lowered into the bypass channel, downstream end first, until it was secured onto the bypass channel weir. Then the lumber was removed and the screen pressed into place in the channel.

We experienced difficulties in maintaining water flow into the fish separator and transfer flume when the water level in the canal headworks dropped below an elevation of 404.1, as was experienced in 1990 and 1991 (Knapp and Ward 1990, Hayes et al. 1992).

We were able to continue sampling in the upper bypass during periods when no water was returned to the river by operating both canal pumps and the secondary pump. Two logistical problems arose when we were in this mode of operation. First, the facility needed to be attended on a daily basis because suckers (Catostomus sp.) passing over the fish separator would block the grates at the entrance to the secondary pump wasteway. Secondly, we needed to be prepared for hauling a large number of river-run fish to the river mouth. A wooden hoist was constructed for lifting containers of water and fish out of the collection facility. Fish were held in 600-gallon circular tanks prior to transport in a 250-gallon slip tank and truck.

Westland Dam

Velocity

Velocity measurements taken in 'front of the drum screens at Westland Canal met agency criteria at moderate canal withdrawals. Baffle boards installed to prevent silt deposition behind the drum screens dampened approach velocities in the upper half of the screens and increased approach velocity near the bottom of screens. Even though discharge through the screens was uneven, most approach velocities near the bottom of the screens were less than 0.3 fps. Velocity measurements will be collected in 1993 to determine whether they meet agency criteria during maximum canal withdrawals and in bypass channel locations.

ACKNOWLEDGMENTS

The planning and implementation of our 1992 evaluation involved many individuals from various agencies. It is our pleasure to acknowledge their assistance and support. Those from our staff include the field crew: Becky Banghart, Jill Berry, Kirk Bradford, Dottie Chan, Dave Guard, Boyd Schrank; and Randy Stephens. We especially thank Boyd Schrank for his assistance with trap designs and preparing figures for this report. We also acknowledge the efforts of Dave Guard in designing traps and field preparations. We thank Todd Hillson for his work on developing the facilities and system for holding test fish at Three Mile Falls Dam. We also thank Mike Hayes for his assistance is sampling plan development and field preparations. We thank other ODFW staff, Mario Solazzi, Kin Daily, Mike Stratton, Dave Ward, and Bob Becker, for loaning equipment, and Bob Becker for transporting test fish from Carson National Fish Hatchery to the study site. We thank Jack Hurst, Ray Hill, and the staff of the Umatilla and Irrigon hatcheries for their logistical support in supplying and loading test fish. We thank Ray Beamesderfer, Mary Buckman, and Emery Wagner for their critical review of the manuscript.

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We extend our appreciation to Jay Marcotte and Jerry Bauer of the Bonneville Power Administration for their assistance with contracting funds.

RECOMMENDATIONS

We recommend the following improvements to ensure safe and effective fish passage through the juvenile fish bypass facility at the WEID Canal.

1. The headgates to the WEID Canal should be automated to ensure proper water level elevations in the forebay and headworks area at all times. A normal operating water surface elevation of 404.1 at the drum screens should be maintained to ensure effective operation of the facility components.

2. When bypass flow does not need to be returned to the canal, the pumpback bay should be operated with a 20% open drain pipe to prevent fish impingement on the traveling screen. A 20% opening of the drain pipe is equivalent to raising the gate stem 5 inches from the fully closed position.

3. In concurrence with the National Marine Fisheries Service, we recommend that only one canal pump be operated when the bypass flow is reduced to 5 cfs. Canal pump #2 should be the preferred pump.

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APPENDIX A

Appendix Table A-l. Ammended median travel time and mean recovery of test fish based on the numbers of test fish released in the WEID Canal juvenile fish bypass facility, Three Mile Falls Dam, Umatilla River, Spring 1991. Median travel times presented by Hayes et al. (1992) were based on the numbers of test fish recaptured after 96 hours.

Species	Release time	Release site[a]	Capture site	Median travel time	Stnd. dev.	N	Mean Recapture (%)	Stnd. dev.	N
CHS	Day	U-H	ST	7.0	6.1	3	77.3	7.6	3
CHF	Day	U-H	ST	6.0	2.8	2	90.0	8.5	2
CHS	Night	U-H	ST	3.5	0.7	2	84.5	7.8	9
CHF	Night	U-H	ST	1.0	0.0	2	88.5	3.5	9
CHS	Day	D-H	ST	3.1	12	9	91.7	8.3	9
CHF	Day	D-H	ST		3.4	6	69.7	15.9	7
STS	Day		ST	33.0	27.6	2	45.0	7.7	6
CHS	Night	D-H	ST	4.2	1.1	9	78.6	6.6	9
CHF	Night	D-H	ST	1.0	0.0	9	87.8	13.3	9

[a] *U-H = upstream of headgates, D-H = downstream of headgates.*
[b] *ST = sampling tank.*

REPORT B

1. Evaluation of adult salmonid passage in the lower Umatilla River

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Department of Natural Resources
Fisheries Program

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ACKNOWLEDGEMENTS

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ABSTRACT

High frequency radio telemetry equipment was purchased, access routes determined and time was spent with University of Idaho biologists learning techniques to apply and monitor radio tags in preparation for an evaluation of adult salmonid passage at irrigation diversions on the Umatilla River.

Operation of the west-bank facility at Three Mile Falls Dam for a one week period indicated that at 700-800 cubic feet per second (cfs) about 25% of the adult summer steelhead (Oncorhvnchus mykiss) migration to the dam utilize the west-bank facility. Adult steelhead captured at the west-bank facility were in excellent condition, with no obvious injuries.

Injuries were not observed on maturing salmonids captured at the east-bank facility of Three Mile Falls Dam at average flows during the fall of 1991 and spring of 1992, as were observed on spring chinook salmon (Oncorhvnchus tshawvtscha) during May 1991. It appeared that changing the steeppass entrance angle eliminated injury problems. Serious injuries were occurring at low water levels when the holding pond pump became non-operational and fish had to be trapped in the top step of the ladder. Spring chinook salmon adults in 1992 that migrated up the' Umatilla River at approximately 40 cfs had many bruises and some abrasions on their ventral surfaces.

Adult coho salmon (Oncorhvnchus kisutch) migrated from the Umatilla boat ramp to Three Mile Falls Dam in as little as two days at flows of 200-250 cfs.

It appears that the amount of attraction water necessary for precise homing of salmonids is much greater than the flows necessary for physical passage in the lower Umatilla River below Three Mile Falls Dam.

Straying of maturing salmonids has been minimal in the Umatilla River spring chinook salmon and steelhead enhancement programs but has been severe in some groups in the fall chinook and coho salmon programs. Analysis of various coded wire tag groups of fall chinook salmon indicated that juvenile salmonid release strategies were an important component in ability to home. To maximize the return of Umatilla River fall chinook salmon to the Umatilla River (minimize straying), juveniles should be reared to age 1+, acclimated and released. If fall chinook salmon are released at age 0+ they should be released at rivermile 80. Lower river releases of age 0+ should not occur because of high straying rates. Although these juvenile salmonid release strategies are important to precise homing, straying of Umatilla River maturing fall chinook salmon will continue to be a serious problem until adequate attraction flows are available. Adaptive water management will be necessary upon completion of phase two of the Umatilla Basin Project to determine time and amount of attraction flow necessary for precise homing.

Background

Native wild r[illegible]nd fall chinook and coho sa[illegible] eliminated i[illegible]River approximately 75 years a[illegible] direct resu[illegible]nd juvenile passage problems [illegible] Umatilla Riv[illegible]passage of adults was seriously ha[illegible] by construct[illegible]ile Falls Dam, Hermiston Power and [illegible] Dam and [illegible]nexistent flows caused by irrig[illegible] diversions. Downstream passage of juveniles was affecte[illegible] unscreened irrigation diversions and low flows. Only indige[illegible] summer steelhead survived, probably because the adults were ab[illegible] wait long periods of time until optimal water conditions permi[illegible] upstream migration to spawn.

Construction of hydroelectric dams on the mainstem Columbia Ri[illegible] heavy fishery exploitation [illegible] spawning and rearing ha[illegible] hindered efforts t[illegible] steelhead returns[illegible] chinook and coh[illegible] the Umatilla [illegible] 12 years ago. From [illegible] through 19[illegible]enile salmon and steelhead [illegible] increased f[illegible] million. The long range goal fo[illegible] Umatilla [illegible]adult salmonids returning in river[illegible] during 19[illegible] of 6,400 adult salmonids returned.

Currentl[illegible]the lower 30 miles of the river mak[illegible] difficul[illegible]e for juvenile downstream migration or [illegible] upstrea[illegible] therefore, trapping and hauling of adu[illegible] juvenil[illegible] often necessary. Improvement of minimu[illegible] levels, [illegible] of the Umatilla Basin Project, should[illegible] juvenil[illegible]lmonids to volitionally migrate. New [illegible] and adu[illegible]assage facilities were constructed [illegible] Mile Fa[illegible]ell, Westland, and Cold Springs [illegible] diversi[illegible]truction of adult passage fa[illegible] Stanfiel[illegible]iversion are scheduled to be co[illegible] the fal[illegible]age of maturing salmonids th[illegible] Westland, [illegible] and Stanfield Irrigati[illegible] various f[illegible] determined.

The major [illegible] were to [illegible] determine th[illegible]etry to stu[illegible] maturing salm[illegible]the irrigatio[illegible] diversions, 2) [illegible] at the west-bank [illegible]

escapement through the lower Umatilla River to Three Mile Falls Dam and 4) determine flow levels necessary for homing to and passage in the Umatilla River to Three Mile Falls Dam.

STUDY SITES

The Umatilla River in northeast Oregon has a drainage area of approximately 2290 square miles and discharges its flow into the Columbia River mainstem just below McNary Dam at the town of Umatilla. Major tributaries are Meacham, McKay, Birch and Butter Creeks. Two storage reservoirs, McKay (73,800 acre feet) and Cold Springs (50,000 af) were constructed primarily for irrigation, but also have value for fish passage, wildlife, recreation and flood control. Five major irrigation diversion dams, Three Mile Falls, Maxwell, Westland, Cold Springs and Stanfield were constructed to channel flows to various irrigation districts. Average flow in the Umatilla River, based on monthly average flows from 1935-1978 at Umatilla are 428 cfs and range from 23 cfs during July to 1096 cfs during April (CTUIR and ODFW, 1990).

Three Mile Falls Dam, constructed in 1914 by the United States Bureau of Reclamation (USBR), is 24 feet high and 915 feet long. Construction of new fish passage facilities were completed in 1988 and included reconstruction of the east and west-bank fish ladders to improve upstream migration of adult salmonids and construction of adult trapping and handling facilities. A low water passage channel was blasted in the basalt bedrock below Three Mile Falls Dam in August thru November of 1984 in a project funded by the Bonneville Power Administration.

Maxwell Diversion Dam at river mile (RM) 14.8 diverts water to the Hermiston Irrigation District. Reconstruction of the facility was completed in 1989. Westland Diversion Dam at RM 27.3 was considered a partial barrier to upstream migration of salmonids until a fish ladder was completed in 1990. A small fish ladder was also constructed at Cold Springs Diversion (RM 29.2) during 1990 and a fish ladder is scheduled to be constructed at Stanfield Irrigation Diversion (RM 32.3) during the fall of 1992.

METHODS

Radio Telemetry

Numerous scientific papers on radio telemetry were read and biologists and factory representatives familiar with the latest technology contacted. Strengths and weaknesses of various radio telemetry systems and frequencies-were discussed with John Eiler, National Marine Fisheries Service (NMFS), Juneau; Lowell Stuehrenberg, NMFS, Seattle; Glen Mendel, Washington Department of Fisheries (WDF), Dayton; Ted Bjornn, University of Idaho, Moscow; Dick Huempfer, Advanced Telemetry Systems, Ron Batten, Lotek Engineering Inc., and Lee Carstensen, Smith Root Inc.

Access routes to monitor radio tagged salmonids from the Umatilla - Columbia River confluence to Stanfield Irrigation Diversion were determined from various maps and aerial photos. Access routes were driven and various landowners contacted.

Time was spent at Ice Harbor and McNary Dams with University of Idaho biologists learning techniques to apply jaw and radio tags to adult steelhead and monitor the radio tags via receiver.

Three Mile Falls Dam - West-Bank

The west-bank fish ladder was operated from December 2-6, 1991 to further define operational problems and to gain experience in facility operations and maintenance. Head differential was maintained at 1.0-1.5 feet from the entrance pool to tailwater as per operational criteria. Video monitoring equipment was operated throughout the five day test period.

Flow was determined from the USBR Umatilla Gage. The entrance V to the holding pond was modified to retain a higher percentage of the salmonids that entered the facility.

Adult Injury Rates and Escapement Through the Lower River to Three Mile Falls Dam

During October and November several weeks were spent attempting to determine the most efficient method to capture adult salmonids below Three Mile Falls Dam to evaluate external injuries and/or mortalities associated with adult upstream migration. During the planning and budgeting process it was felt that large mesh seines would probably be the most efficient capturing technique, but investigations at extremely low water indicated that there were very few areas where fish hold that could be seined because of a very uneven bottom contour in the basalt bedrock.

Attempts were thus made to capture adult salmonids at and near Chinaman's Hole and the Grapevine Hole area by dipnet and D.C. backpack electroshocker. Captured fish were marked with a single hole punch (paper punch) in the lower half of the caudal fin and released. Visual observations to assess injury rates were conducted at the Three Mile Falls Dam east-bank capture facility.

Adult coho salmon recycled from the Three Mile Falls Dam east-bank capture facility to the Umatilla boat ramp were given various opercle punches.

Escapement surveys were conducted below Three Mile Falls Dam to 100 yards below Chinaman's Hole to determine if adult salmonid passage problems were occurring and to enumerate and sample the escapement.

Adult spring chinook salmon stranded by low flows in the river below Three Mile Falls Dam were captured by dipnet or seine, observed for injuries associated with passage, and either sampled (most adipose with coded wire tag) or hauled upriver and released.

Homing to and Passage in the Umatilla River

Available data on salmonids of Umatilla River origin was analyzed to attempt to determine the time and amount of flow necessary to maximize return to and migration in the Umatilla River. Data sources were: Coded wire tag recovery information from Pacific States Marine Fisheries Commission (PSMFC) and WDF, Umatilla Gage information from the USBR, salmonid timing at Three Mile Falls Dam from Confederated Tribes of the Umatilla Indian Reservation (CTUIR) files and McNary Dam fallback data on fall chinook and steelhead from WDF.

In the analysis of homing vs. straying only terminal recoveries (spawning grounds, enhancement facility or Threemile Falls Dam) were compared.

The percentage of fall chinook salmon homing to the Umatilla River was determined for acclimated and direct released groups by freshwater age and year of return.

To determine when various maturing Umatilla River salmonids return to the Umatilla-Columbia River confluence, all coded wire tag recoveries from Columbia River fisheries were compiled and analyzed.

RESULTS

Radio Telemetry

High frequency (150 MH,) radio telemetry equipment was ordered from Lotek Engineering, Inc. on February 18, 1992. It appeared that high frequency would give the best signal strength and Lotek appeared to make state-of-the-art receivers. The University of Idaho had successfully utilized high frequency Lotek equipment at Ice Harbor Dam during 1991.

The equipment was not ordered until February 18, 1992 because of a contract modification, which was necessary to purchase the Lotek receiver rather than adult capture seines. At that time Lotek verbally stated that the radio telemetry equipment would be shipped in late April or early May. The equipment actually arrived on June 11, 1992. The radio tagging feasibility study could not be conducted on spring chinook salmon and steelhead because of the late delivery date and a severe drought that precluded adult migration in the lower Umatilla River. It was initially thought that if radio tags were not received until after the spring chinook salmon migration that radio tagging would be conducted on the spawning grounds to develop handling and monitoring techniques. Low and warm water was already severely stressing the chinook salmon escapement and additional handling was not warranted. The radio telemetry feasibility study will be conducted during the migration of fall chinook and coho salmon and steelhead.

Three Mile Falls Dam - West-Bank

During December 3-6, 1991 a total of 313 summer steelhead were enumerated at Three Mile Falls Dam. Twenty four percent of the total were enumerated in the west-bank trap or ladder and 76% were enumerated in the east-bank trap (Table 1). All steelhead enumerated in the west-bank facility appeared to be in good condition with no obvious external injuries.

It appears that if the west-bank facility was operated in the bypass mode under current criteria that adult salmonid passage would not be a problem. However, the facility has severe problems associated with trapping and hauling and/or sampling of adult salmonids. The following list of problems are associated with trapping and hauling and/or sampling of adult salmonids at the west-bank facility: the crowder won't lift high enough to get the fish to the transport chamber, the V notch horizontal bars are too wide to retain fish in the trap, there is no automatic stop on the horizontal crowder, the backlight has water in the chamber.

Adult Injury Rates and Escapement through the Lower River to Three Mile Falls Dam

The DC backpack electroshocker was fairly efficient at capturing coho salmon adults in very low flow areas but no fall chinook salmon or steelhead were captured. Dipnetting by tribal members in the Chinaman's Hole area was largely unsuccessful, probably because no partial barriers to migration exist and thus large numbers of fish do not hold in any one area.

Observations at the east-bank trapping facility of Three Mile Falls Dam during the fall and spring adult salmonid migrations indicated that extremely few mechanical injuries were occurring compared to injuries observed during the spring migration in 1991.

Severe injuries have been observed when spring chinook salmon were trapped in the top step of the fish ladder, probably associated with jumping at attraction flow and hitting the metal grate that keeps fish from bypassing the facility. In addition, almost all spring chinook salmon that migrated upstream to or near Three Mile Falls Dam during late May through mid June at very low flows (40 cfs) had many abrasions and severe bruises on their ventral surfaces.

On November 8, 1991 a total of 145 adult coho salmon (excess to escapement needs) were captured at the east bank trapping facility, marked by left opercle punch and transported by truck to the Umatilla Boat Ramp near the mouth of the Umatilla River. Most of the coho salmon were in an advanced state of sexual maturity (running milt or eggs) yet 11.0% migrated to the dam within two days and a total of 29.0% returned within four days. At river flows of 200-250 cfs it appears that coho salmon had little difficulty migrating through the lower river to Three Mile Falls Dam.

Table 1. Comparison of summer steelhead captured at Threemile Falls Dam east and west bank, 1991.

Date	Flow [1/] (cfs)	East Bank Steelhead		West Bank Steelhead	
		n	%	n	%
12/3/91	830	38	69.1	17	30.9
12/4/91	768	69	69.7	30	30.3
12/5/91	754	86	86.0	14	14.0
12/6/91	825	45	76.3	14	23.7
Total		238	76.0	75	24.0

1/ Umatilla Gage

A total of 107 coho salmon and 16 adult fall chinook salmon were sampled 'below Threemile Falls Dam (Table 2). Of the coho salmon sampled, 43.2% were classified as prespawning mortalities and 56.8% were partially spawned or spawned out (Appendix A). The percentage of the minimum total return of coho salmon to the Umatilla River sampled below Three Mile Falls Dam increased in 1991 over the two previous years (Table 3). The high prespawning mortality discussed previously indicates that the general health of a portion of the escapement was probably poor and a new slough area developed for coho salmon spawning on the east side of Chinaman's Hole, because of the higher than normal fall flows.

Only 16 adult fall chinook salmon were sampled below Three Mile Falls Dam despite increased sampling effort over 1989 and 1990 (Appendix B). It is apparent that a much lower percentage of the fall chinook salmon return spawned below the dam than has been observed during the last several years (Table 4).

Adult fall chinook salmon coded wire tag recoveries from fish spawning below Three Mile Falls Dam from past years were all from juveniles acclimated at Bonifer or Minthorn Springs and released at age 1+ except for one age 0+ released at rivermile 1.5.

Comparison of fall escapement survey information collected below Three Mile Falls Dam from 1989-1991 is presented in Appendix C.

Homing to and Passage in the Umatilla River

During 1990 and 1991, the first two years of significant spring chinook salmon adult returns to the Umatilla River, the fish homed fairly precisely (less than 5% strayed). Flows during April and May were thus adequate (Figure 1-2) for attraction and passage of adults. The juveniles that contributed to the adult return were from the 1986-1987 brood years all reared off site, acclimated for approximately three weeks at Bonifer or Minthorn and released at age 1+. Since adult attraction flows for the 1992 return were much reduced (Figure 3) it will be important to determine if the straying rate varied dramatically.

Analysis of various coded wire tag groups of fall chinook salmon indicated that release strategies were an important component in ability to home (return to Three Mile Falls Dam) (Tables 5-9). During the fall of 1989, acclimated freshwater age 1+ fall chinook salmon from the 1985 and 1986 broods had a weighted average homing rate of91.4%,but of individual groups varied between 61.8% and 98.9%. Percentage homing of these groups declined about 10% during 1990 returns and an additional 20% during 1991 returns. Thus the weighted rate of homing in 1991 was about 61.2% for acclimated 1985 and 1986 brood fall chinook salmon. A group of 1984 brood fall chinook salmon acclimated at Bonifer and Minthorn had only a homing rate of 23.6% during the 1989 return year. Thus it is obvious that some groups of acclimated fall chinook salmon juveniles have imprinted to a higher degree than other groups as attraction water was the same for all the 1989 adult return.

Table 2. Umatilla River fall chinook and coho salmon escapement surveys below Threemile Falls Dam, 1991.

Location	Date	Salmonids Observed			Salmonids Sampled			Redds Enumerated
		CHF	Coho	Unid	CHF	Coho	Unid	
Chinaman's Hole Area	10/30/91	0	0	0	0	12	0	0
Chinaman's Hole Slough	11/4/91	0	0	0	0	2	0	0
Threemile Dam to China Hole	11/5/91	2	12	0	0	26	0	6
Chinaman's Hole Slough	11/5/91	0	56	0	0	0	0	0
Chinaman's Hole Slough	11/6-7/91	0	43	0	0	13	0	0
Threemile Dam to China Hole	11/13/91	16	46	0	1	21	0	20
Chinaman's Hole slough	11/13/91	0	0	0	0	8	0	0
Chinaman's Hole Slough	11/14/91	0	17	0	0	6	0	0
Chinaman's Hole Slough	11/21/91	0	8	0	0	3	0	0
Threemile Dam to China Hole	11/25/91	4	20	0	13	9	0	9
Chinaman's Hole Slough	11/25/91	0	10	0	1	2	0	0
Threemile Dam to China Hole	12/18/91	0	0	0	1	5	1	0
TOTAL					16	107	1	35

Table 3. Minimum estimate of return of coho salmon adults to the Umatilla River 1989-1991.

Year	Adults enumerated @ Threemile Falls Dam	Adults sampled below Threemile Dam	Total Minimum return	Percentage of minimum return spawning below Threemile Dam
1989	4108	44	4152	1.1%
1990	410	2	412	.5%
1991	1732	107	1839	5.8%

Table 4. Minimum estimate of return of fall chinook salmon adults to the Umatilla River 1989-1991.

Year	Adults enumerated @ Threemile Falls Dam	Adults sampled below Threemile Dam	Total Minimum return	Percentage of minimum return spawning below Threemile Dam
1989	279	89	368	24.2%
1990	333	110	443	24.8%
1991	522	16	538	3.0%

Figure 1

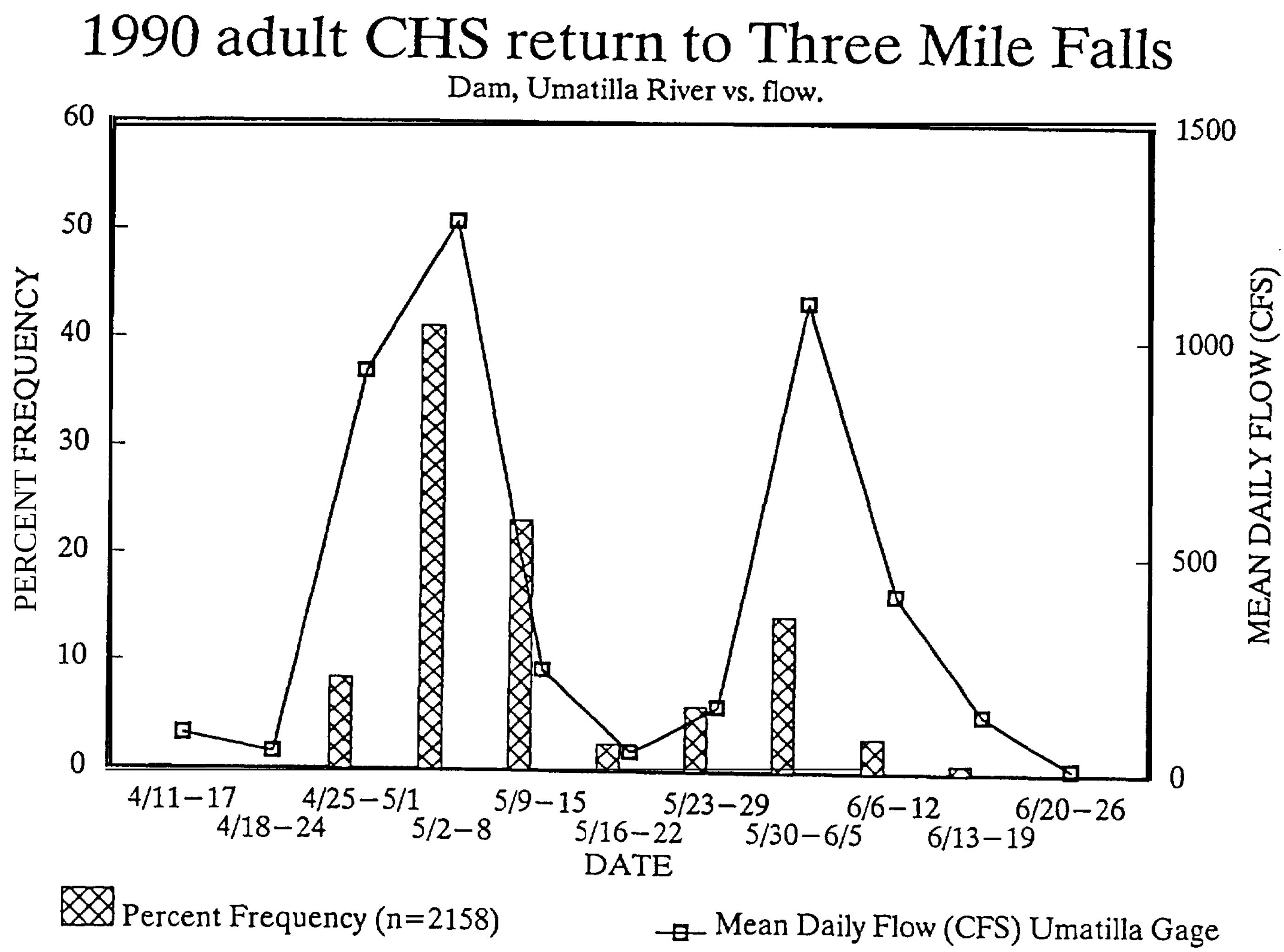
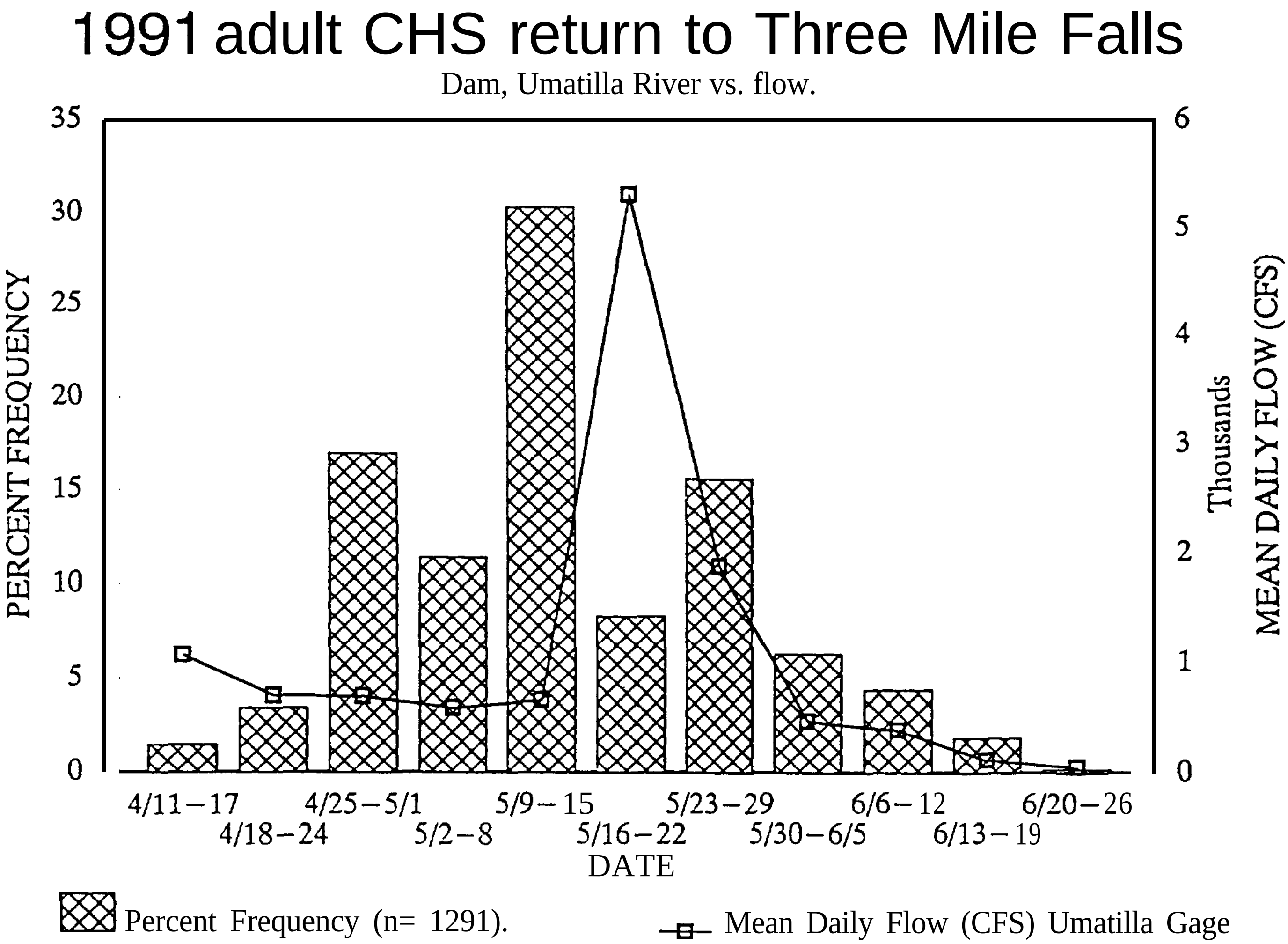

1990 adult CHS return to Three Mile Falls
Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
60
50
40
30
20
10
0
MEAN DAILY FLOW (CFS)
1500
1000
500
0
4/11-17
4/18-24
4/25-5/1
5/2-8
5/9-15
5/16-22
5/23-29
5/30-6/5
6/6-12
6/13-19
6/20-26
DATE
Percent Frequency (n=2158)
Mean Daily Flow (CFS) Umatilla Gage

Figure 2.



1991 adult CHS return to Three Mile Falls
Dam, Umatilla River vs. flow.
35
30
25
20
15
10
5
0
PERCENT FREQUENCY
6
5
4
3
2
1
0
Thousands
MEAN DAILY FLOW (CFS)
4/11-17
4/18-24
4/25-5/1
5/2-8
5/9-15
5/16-22
5/23-29
5/30-6/5
6/6-12
6/13-19
6/20-26
DATE
Percent Frequency (n= 1291).
Mean Daily Flow (CFS) Umatilla Gage

Figure 3.

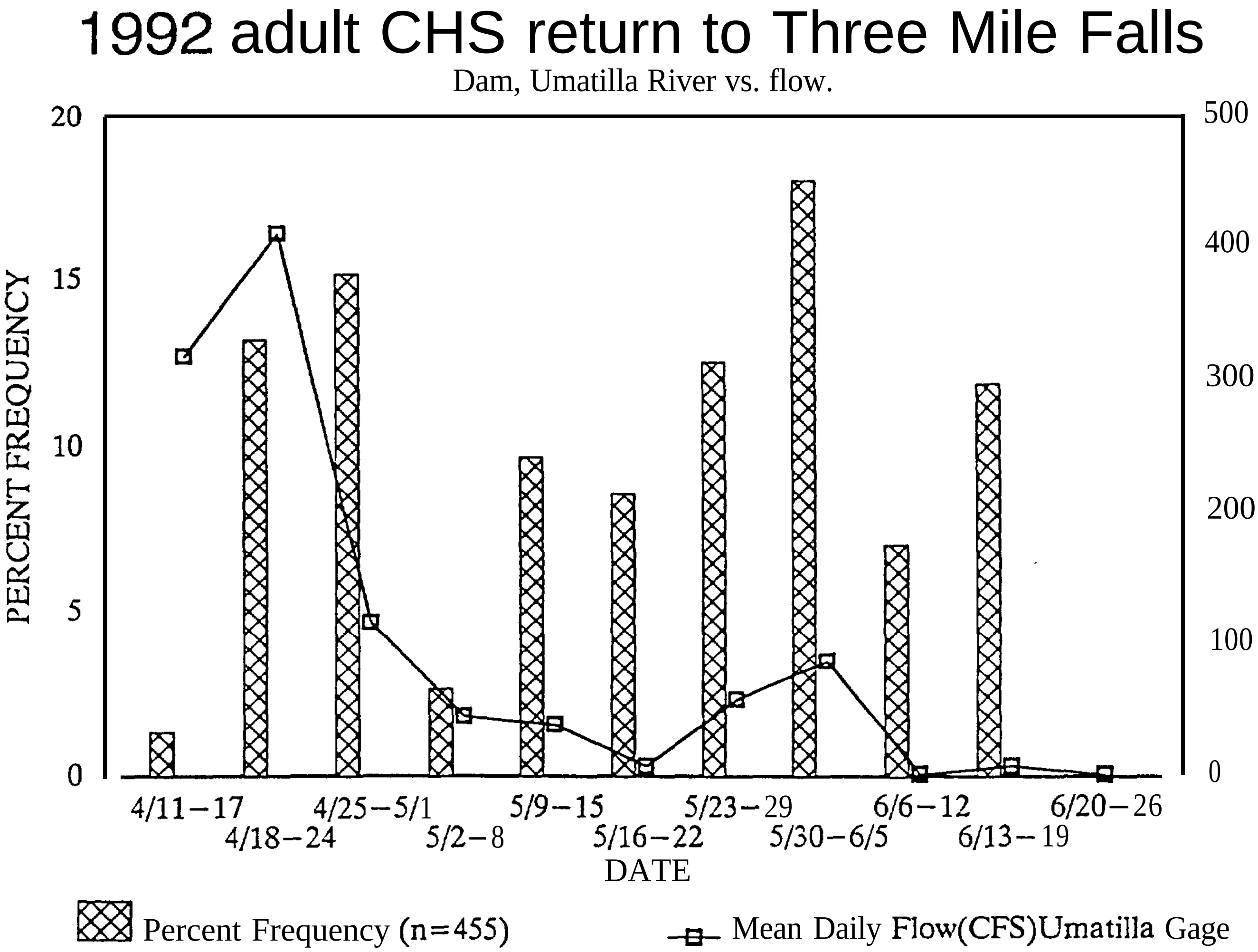

1992 adult CHS return to Three Mile Falls
Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
20
15
10
5
0
MEAN DAILY FLOW (CFS)
500
400
300
200
100
0
4/11–17
4/18–24
4/25–5/1
5/2–8
5/9–15
5/16–22
5/23–29
5/30–6/5
6/6–12
6/13–19
6/20–26
DATE
Percent Frequency (n=455)
Mean Daily Flow(CFS)Umatilla Gage

Table 5. Percentage of fall chinook salmon homing to the Umatila River by age at release and direct vs. acclimated groups.

Preliminary Data

Return Year	Directed Released		Acclimated		
	0+	0++	0+	0++	1+
1989	n = 218	n = 5	n = 10	n = 0	n = 315
	% = 7.3	% = 100	% = 20.0	% = 0	% = 75.9
1990	n = 62	n = 24	n = 6	n = 0	n = 222
	% = 19.4	% = 66.7	% = 83.3	% = 0	% = 80.2
1991	n = 57	n = 39	n = 10	n=1	n = 134
	% = 42.1	% = 59.0	% = 60.0	% = 100.0	% = 61.2

0+ = Spring or summer release
0++ = Fall release

Table 6. Percentage of fall chinook salmon homing to the Umatilla River from acclimated releases, 1989-1991.

Preliminary Data

Tag Code	Area Juveniles .,&&leased	Age at Release	Return Year 1989	1990	1991
7-38-23/27	Minthorn	1+	n=40	n=26	n=7
			%=87.5	%=80.8	%=71.4
7-40-38/39	Minthorn	1+	n=90	n=95	n=70
			%=98.9	%=88.4	%=65.7
7-38-28/32	Bonifer	1+	n=34	n=36	n=7
			%=61.8	%=50.0	%=28.6
7-40-36/37	Bonifer	1+	n=79	n=64	n=50
			%=97.5	%=84.3	%=58.0
7-33-27	Bon & Min	1+	n=72	n=0	n=0
			%=23.6	%=0	%=0
7-45-39/41	Minthorn	0+	n=0	n=2	n=5
			%=0	%=50.0	%=40
7-47-53,54,57	Minthorn	0+	n=0	n=4	n=5
			%=0	%=100.0	%=80.0
7-31-62	Bonifer	0+	n=9	n=0	n=0
			%=22.2	%=0	%=0
7-53-25/27	Minthorn	0++	n=0	n=0	n=1
			%=0	%=0	%=100.0

0+ = Spring or summer release
0++ = Fall release

Table 7. Percentage of fall chinook salmon homing to the Umatilla Riover from direct releases, 1989-1991.

Preliminary Data

Tag Code	Area Juveniles Released	Age at Release	Return Year		
			1989	1990	1991
7-33-26	Mile 1.5	0+	n=76		
			%=1.3		
7-38-33/42	Mile 1.5	0+	n=83	n=11	n=1
			%=0	%=0	%=0
7-39-12/14	Mile 1.5	0+	n=45	n=38	n=12
			%=11.1	%=7.9	%=0
7-50-07	Mile 23.0	0+	n=14	n=2	n=10
			%=71.4	%=50.0	%=40.0
7-46-46/48	Mile 23.0	0+	n=0	n=6	n=18
			%=0	%=50.0	%=27.8
7-45-36/38	Mile 63.0	0++	n=5	n=24	n=34
			%=100.0	%=66.7	%=58.9
7-47-58,60,63	Mile 63.0	0++	n=0	n=0	n=5
			%=0	%=0	%=60.0
7-53-22/24	Mile 63.0	0++	n=0	n=0	n=0
			%=0	%=0	%=0
7-54-03/05	Mile 70.9	0+	n=0	n=5	n=16
			%=0	%=100.0	%=93.8

0+ = Spring or summer release
0++ = Fall release

Preliminary Data

Table 8. Return of Umatilla River Direct Released Age 0+ and 0++ Fall Chinook Salmon to Columbia River Terminal Areas 1989-1991.

Release Mile	Umatilla Returns	Returns to Other Areas	n
1.5	3.4%	96.6%	265
23.0	46.0%	54.0%	50
63.0	64.7%	35.3%	68
70.0 - 79.0	95.2%	4.8%	21

0+ = Spring or summer release
0++ = Fall release

Preliminarv Data

Table 9. Returns of Umatilla River direct released vs. acclimated fall chinook salmon to Columbia River Terminal Areas 1989-1991.

	Percentage Return to the Umatilla River		Percentage Return to the Umatilla River	
Return Year	Direct Release 0+	n	Acclimated 0+, 1+	n
1989	9.4%	223	74.2%	325
1990	32.6%	86	80.3%	228
1991	49.0%	96	61.4%	145

Homing of maturing fall chinook salmon from juveniles that had been direcily released into the Umatilla River was extremely poor for lower river releases (mile 1.5) but improved the further upriver the juveniles were released.

Coho salmon adult straying from the 1988-1991 return years varied between 6.0% and 47.3% for coho salmon of Tanner Creek origin reared at Cascade Hatchery and released in the Umatilla River at age 1+ (Table 10). A high percentage of the strays actually returned to their rearing facility and thus they appear to have imprinted before release into the Umatilla River.

Table 10. Homing vs. Straying of adult (age 1.1) coho salmon from juveniles reared at Cascade Hatchery and released into the Umatilla River.

Return Year	Number Strayed	% Strayed	Number Homed	% Homed
1988	13	28.9	32	71.1
1989	20	6.0	314	94.0
1990	24	38.7	38	61.3
1991	141	47.3	157	52.7

Fall chinook salmon harvest timing data from 1984-1989 was compiled by zone, as subarea data was not available until 1990. (Figure 4). During 1990 adult Umatilla river fall chinook salmon were first harvested in the John Day Pool during the period August 24-30 and the catch peaked in mid September (Figure 5).

Significant numbers of fall chinook and coho salmon did not migrate to Three Mile Falls Dam until after mid-October in 1990 and 1991, when flows were approximately 150 cfs or greater (Figures 6-8). However, during 1989 average flows exceeded 150 cfs during the first two weeks of October, yet very few fish migrated to Three Mile Falls Dam until the period October 19-26.

High water temperatures in the Umatilla River could be a delaying factor in entry timing of fall chinook and coho salmon from the Umatilla-Columbia River confluence to Three Mile Falls Dam (Figures 9-11). It appears that many maturing fall chinook and coho salmon are in the area above Bonneville Dam to the John Day Pool (Zone 6) for 3 to 4 weeks before migrating into the Umatilla River from mid-October to mid-November.

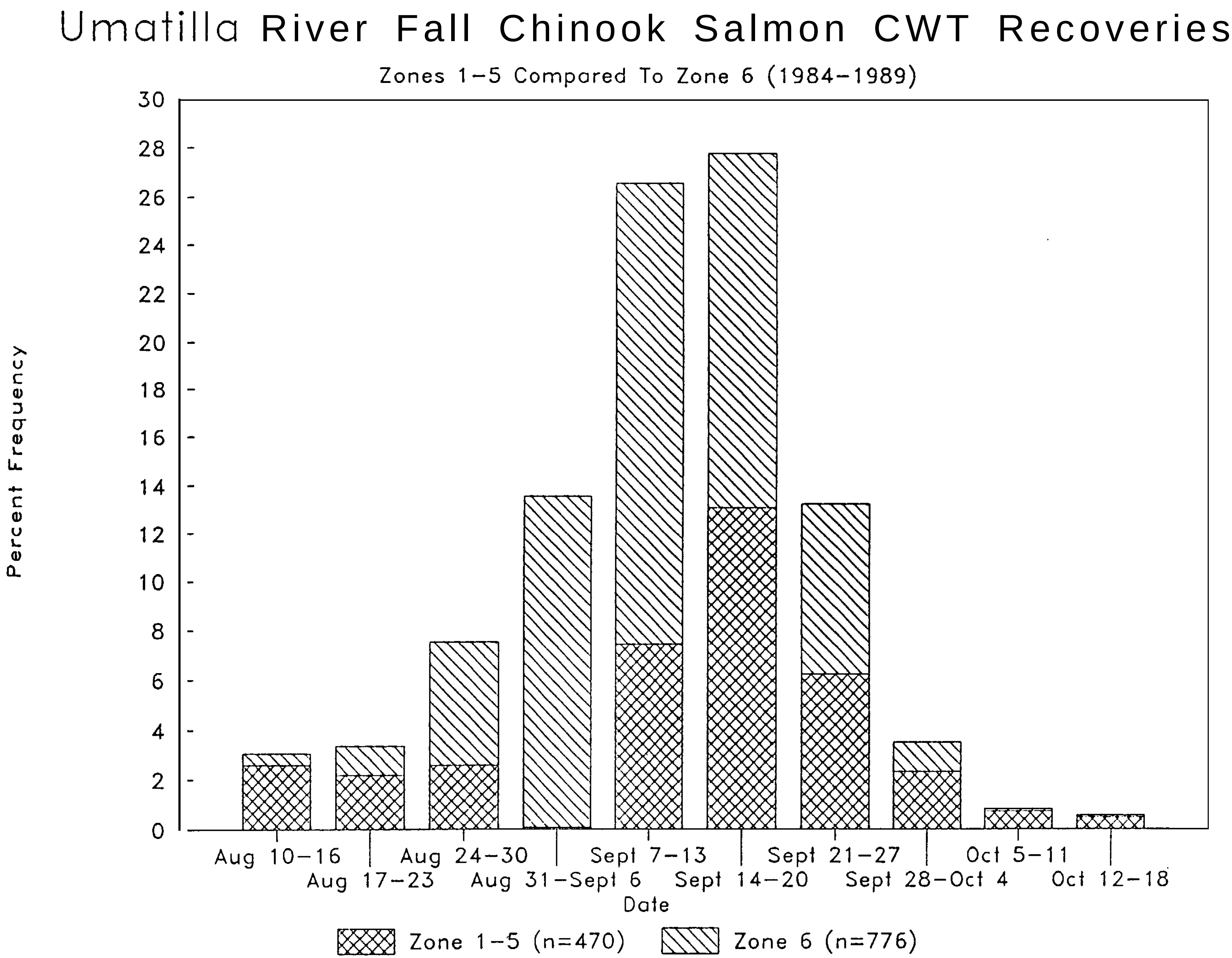

Umatilla River Fall Chinook Salmon CWT Recoveries
Zones 1-5 Compared To Zone 6 (1984-1989)
Percent Frequency
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Aug 10-16
Aug 17-23
Aug 24-30
Aug 31-Sept 6
Sept 7-13
Sept 14-20
Sept 21-27
Sept 28-Oct 4
Oct 5-11
Oct 12-18
Date
Zone 1-5 (n=470)
Zone 6 (n=776)

Figure 4.

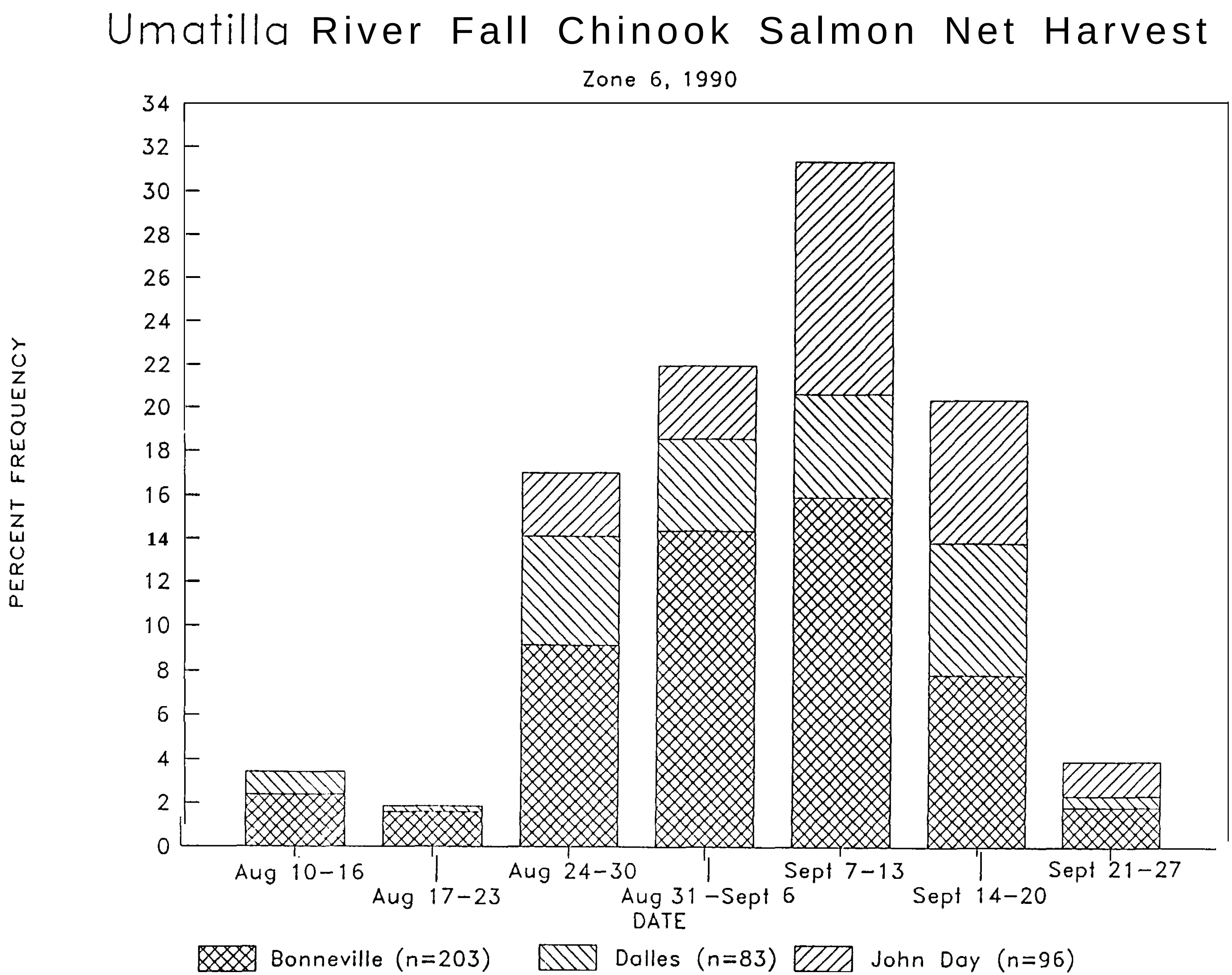

Umatilla River Fall Chinook Salmon Net Harvest
Zone 6, 1990
PERCENT FREQUENCY
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Aug 10-16
Aug 17-23
Aug 24-30
Aug 31 -Sept 6
Sept 7-13
Sept 14-20
Sept 21-27
DATE
Bonneville (n=203)
Dalles (n=83)
John Day (n=96)

Figure 5.

Figure 6.

1989 adult CHF & COHO return to Three Mile

Falls Dam, Umatilla River vs. flow.

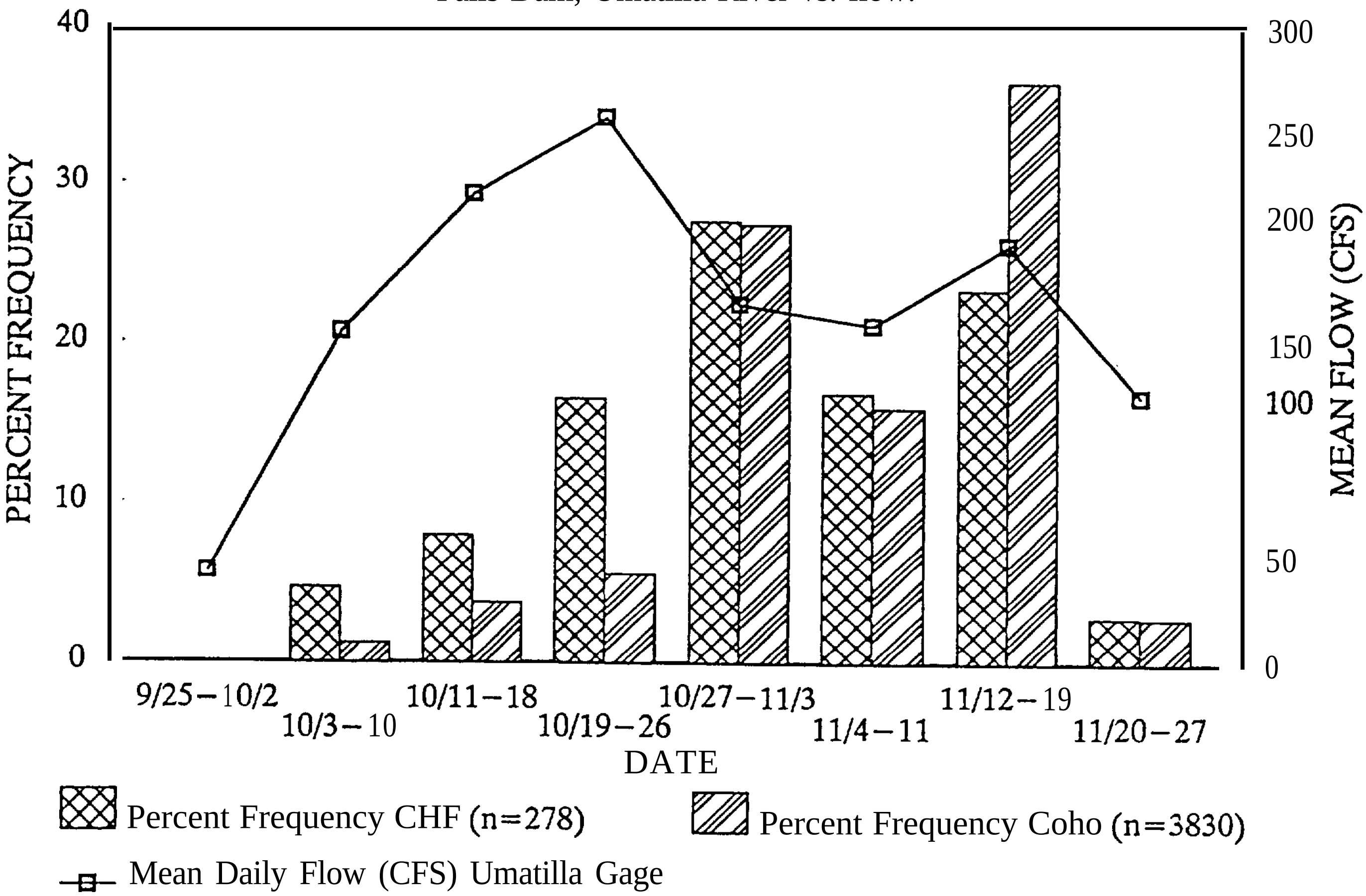


Figure 7.

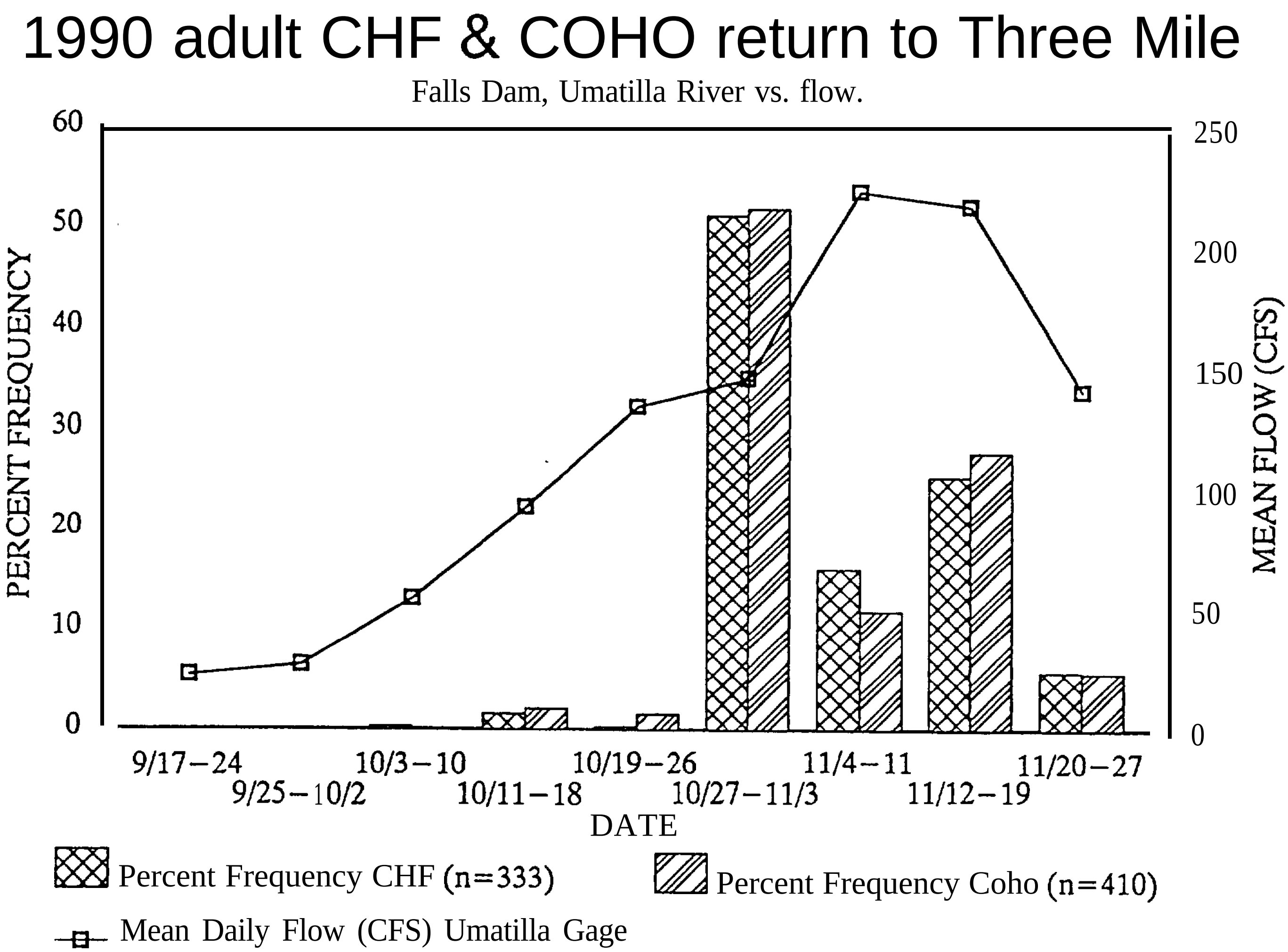

1990 adult CHF & COHO return to Three Mile
Falls Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
MEAN FLOW (CFS)
60
50
40
30
20
10
0
250
200
150
100
50
0
9/17–24
9/25–10/2
10/3–10
10/11–18
10/19–26
10/27–11/3
11/4–11
11/12–19
11/20–27
DATE
Percent Frequency CHF (n=333)
Percent Frequency Coho (n=410)
Mean Daily Flow (CFS) Umatilla Gage

Figure 8.

1991 adult CHF & COHO return to Three Mile

Falls Dam, Umatilla River vs. flow.

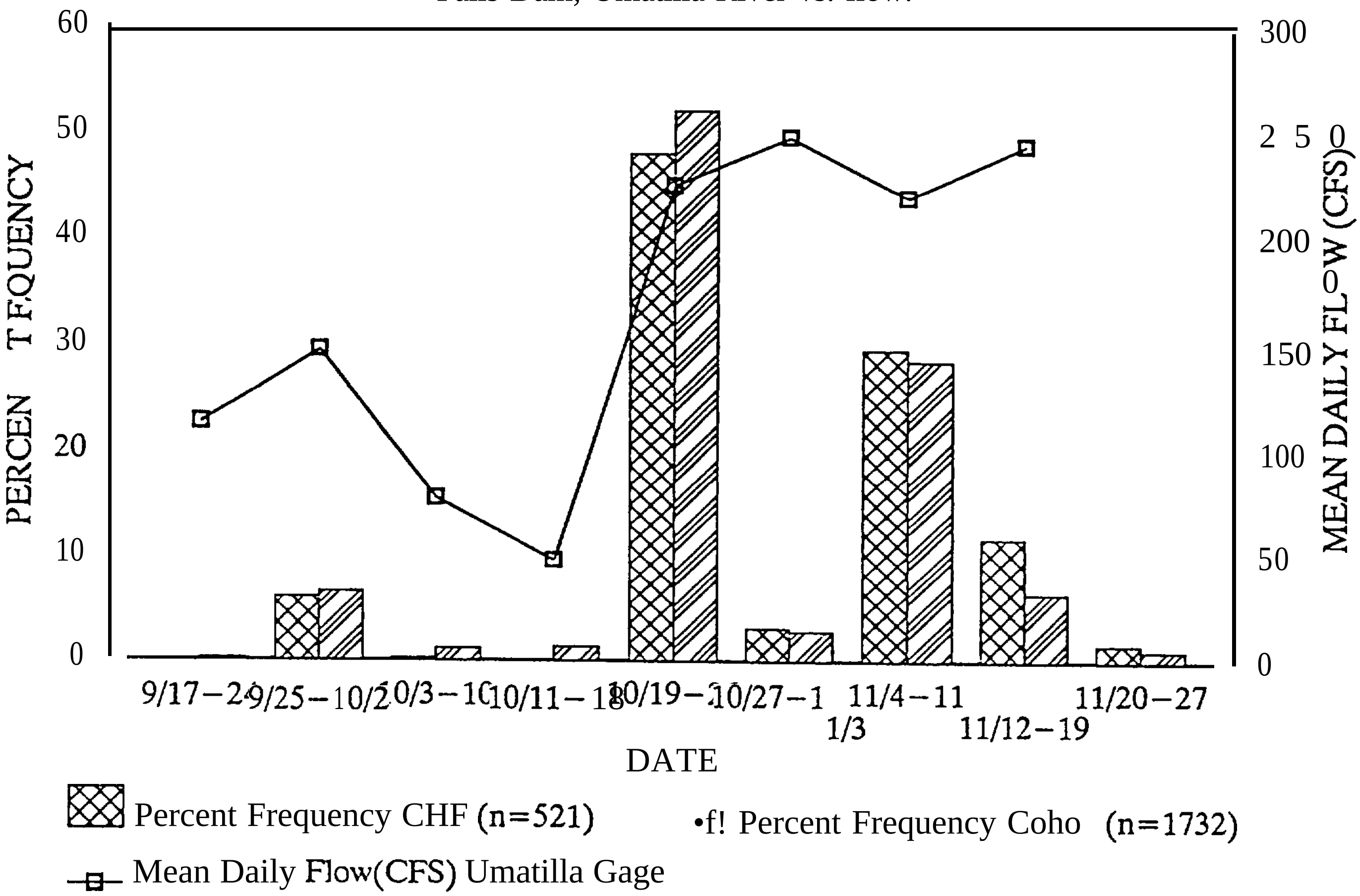


Figure 9.

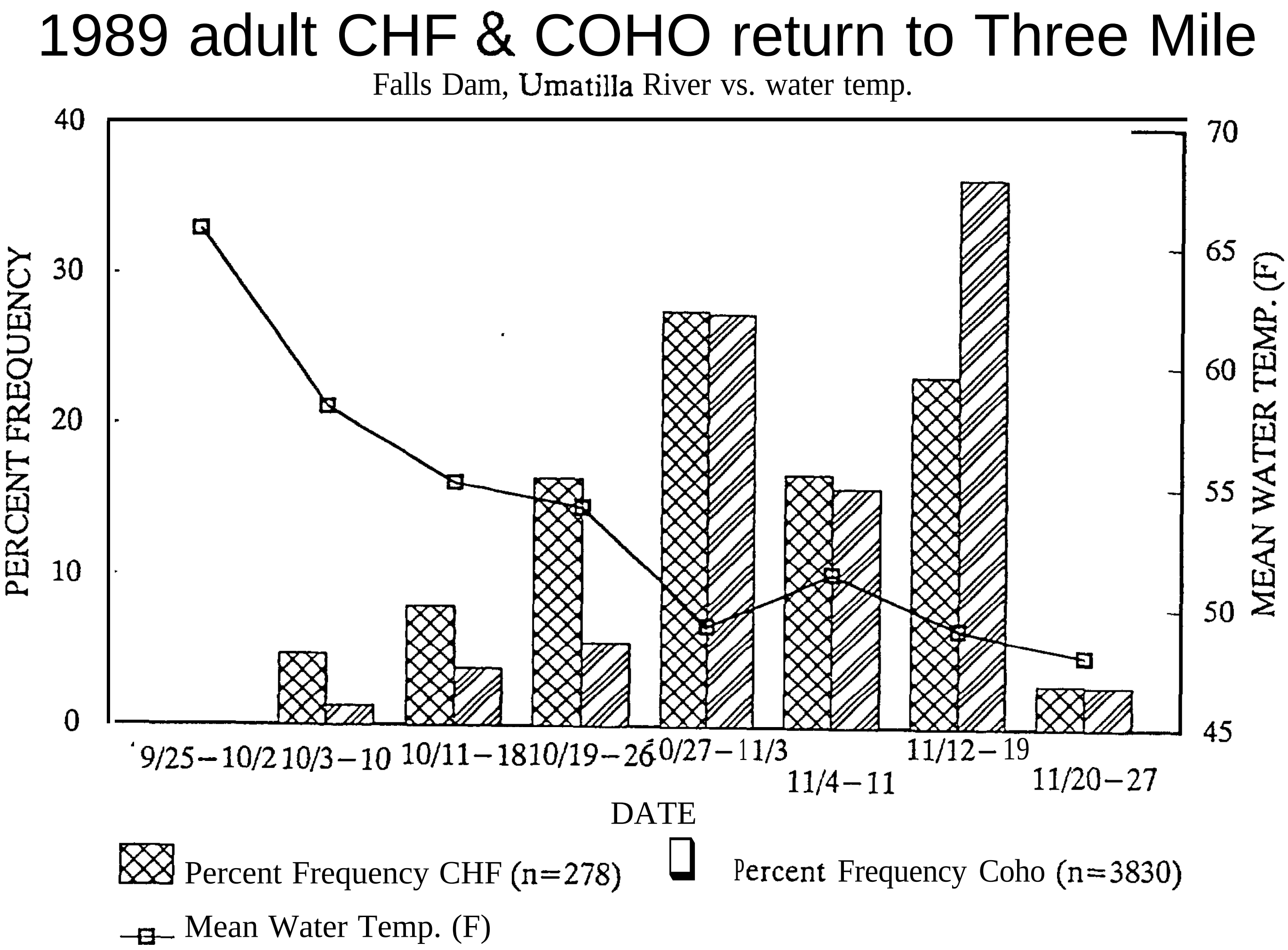

1989 adult CHF & COHO return to Three Mile
Falls Dam, Umatilla River vs. water temp.
40
30
20
10
0
70
65
60
55
50
45
PERCENT FREQUENCY
MEAN WATER TEMP. (F)
9/25-10/2
10/3-10
10/11-18
10/19-26
10/27-11/3
11/4-11
11/12-19
11/20-27
DATE
Percent Frequency CHF (n=278)
Percent Frequency Coho (n=3830)
Mean Water Temp. (F)

Figure 10.

1990 adult CHF & COHO return to Three Mile

Falls Dam, Umatilla River vs. water temp.

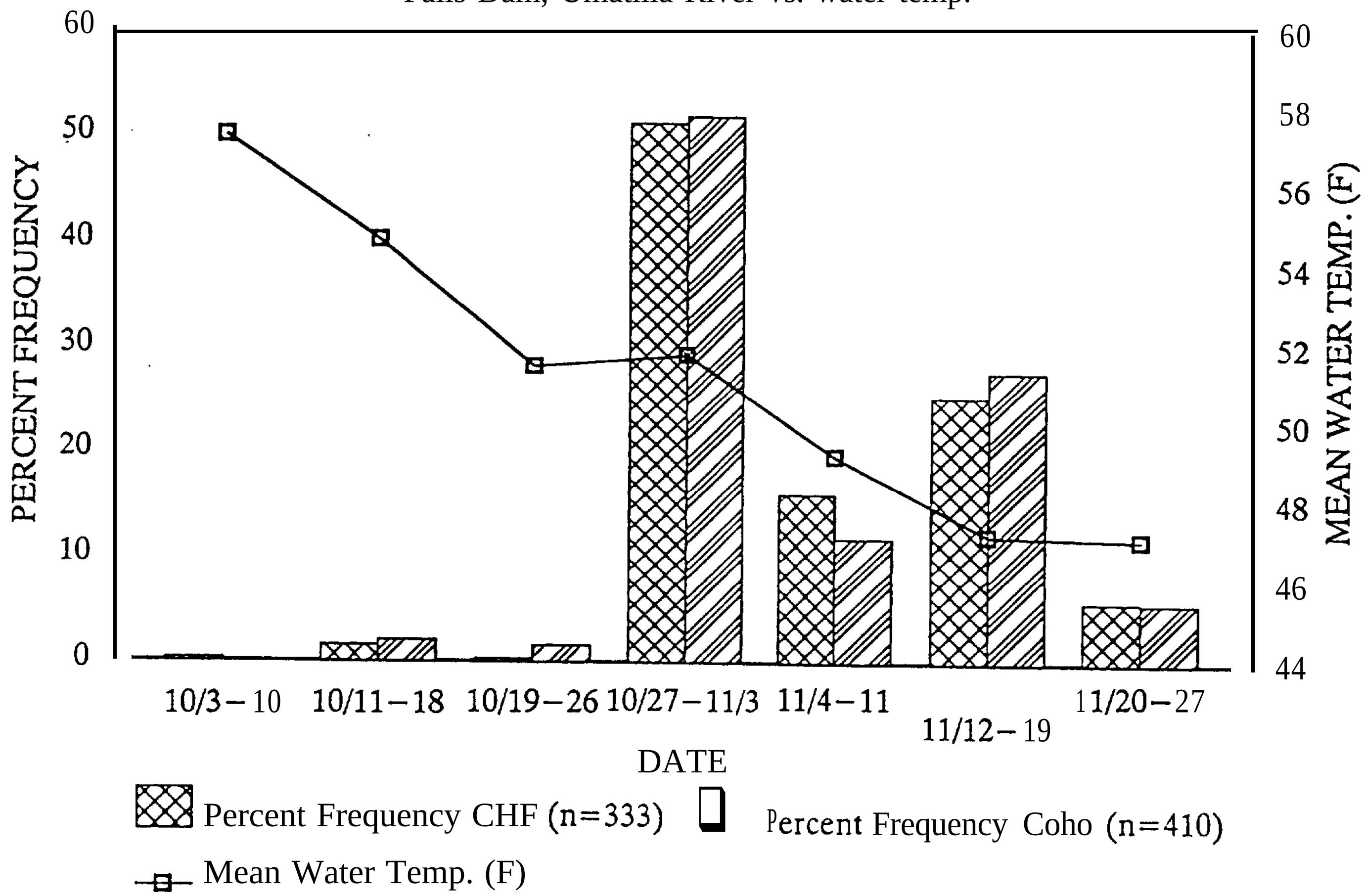
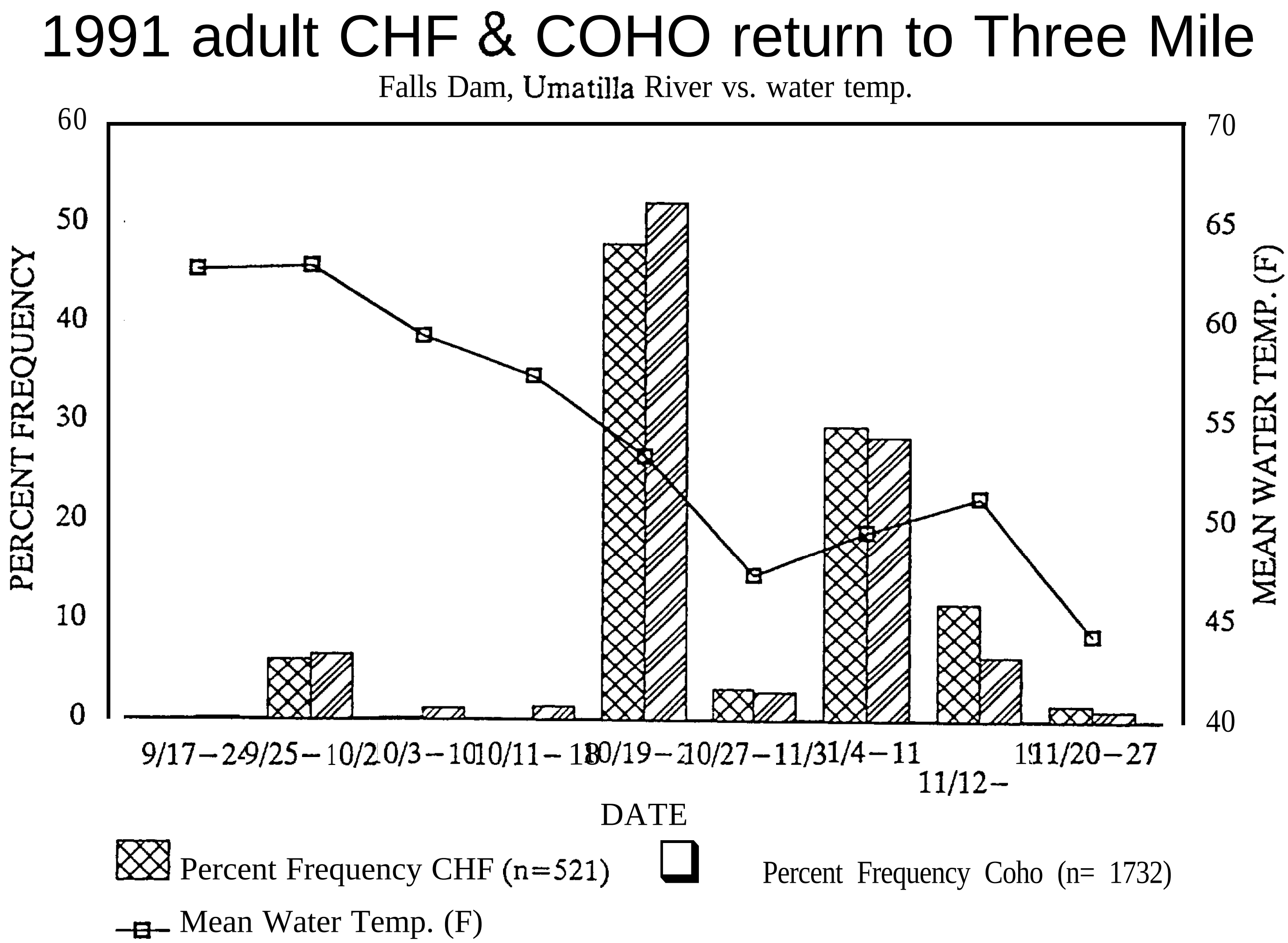


Figure 11.



1991 adult CHF & COHO return to Three Mile
Falls Dam, Umatilla River vs. water temp.
PERCENT FREQUENCY
MEAN WATER TEMP. (F)
0
10
20
30
40
50
60
40
45
50
55
60
65
70
9/17-24
9/25-10/2
10/3-10
10/11-18
10/19-26
10/27-11/3
11/4-11
11/12-19
11/20-27
DATE
Percent Frequency CHF (n=521)
Percent Frequency Coho (n= 1732)
Mean Water Temp. (F)

In 1991 approximately 100 cfs of McKay storage water was released starting in mid September to attempt to attract Umatilla River fall chinook and coho salmon into the Umatilla River and reduce straying into the upper Columbia River drainage. The majority of the adult escapement did not enter the river until mid-October when flows were above 200 cfs and straying was still a problem.

Coho salmon bound for the Umatilla River enter the Columbia River later than Umatilla fall chinook salmon (Figure 12) so attraction flows from the Umatilla River to minimize the potential for straying should be keyed to the timing of Umatilla River fall chinook salmon in Zone 6.

Spring chinook salmon bound for the Umatilla River are caught in Zone l-5 in the Columbia River as early as mid-February, but the majority of the harvest occurs during the April 16-30 ceremonial fishery in Zone 6 (Figure 13). Because of the small number of Umatilla River spring chinook harvested in the Columbia River it is difficult to determine run timing to the Umatilla-Columbia River confluence.

Small numbers of Umatilla River summer steelhead are caught in the Zone 6 fishery from August 1 through October 31 (Figure 14). The small harvest again makes determination of run timing to the Umatilla-Columbia River confluence difficult.

The wild steelhead population has survived in the Umatilla River because of their life history which allows six months or more between entry into the Columbia River and spawning in the Umatilla River. Entry timing and flow to migrate to Three Mile Falls Dam is thus quite variable (Figures 15-19).

Passage of adult salmonids from the Umatilla-Columbia River confluence to Three Mile Falls Dam appears to be a problem only at very low (and probably extremely high) flows. For example, spring chinook salmon have been observed migrating up the Umatilla River at average weekly flows of 5308 cfs to 40 cfs during the 1990-1992 return years. Spring chinook that migrated to Three Mile Falls Dam at approximately 40 cfs (1992) had severe bruising on their ventral surfaces but spring chinook salmon returning earlier during 1992 at weekly flows averaging 411 to 117 cfs were in excellent condition.

DISCUSSION

Radio Telemetry

Radio telemetry studies should be valuable in determining if adult passage problems exist at the upper four irrigation diversions at various flow levels. Radio tagging will also help define flow requirements for releasing adult salmonids at Three Mile Falls Dam rather than trucking them upstream. The current criteria is that they will be hauled if during the next 30 days flows are predicted to drop below 150 cfs.

Figure 12.

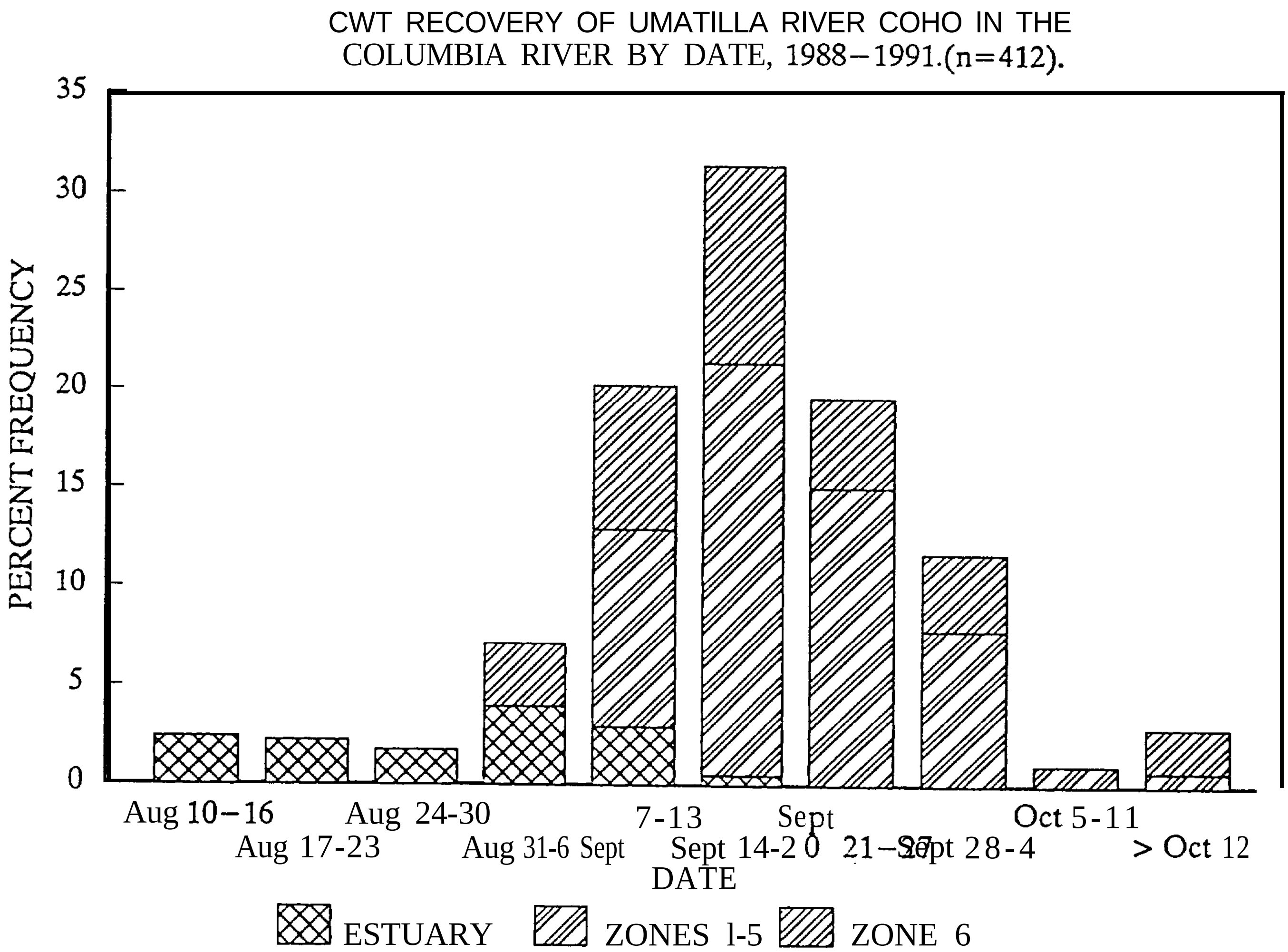

CWT RECOVERY OF UMATILLA RIVER COHO IN THE COLUMBIA RIVER BY DATE, 1988-1991.(n=412).
35
30
25
20
15
10
5
0
PERCENT FREQUENCY
Aug 10-16
Aug 17-23
Aug 24-30
Aug 31-6 Sept
7-13
Sept 14-20
Sept 21-27
Sept 28-4
Oct 5-11
> Oct 12
DATE
ESTUARY
ZONES 1-5
ZONE 6

Figure 13.

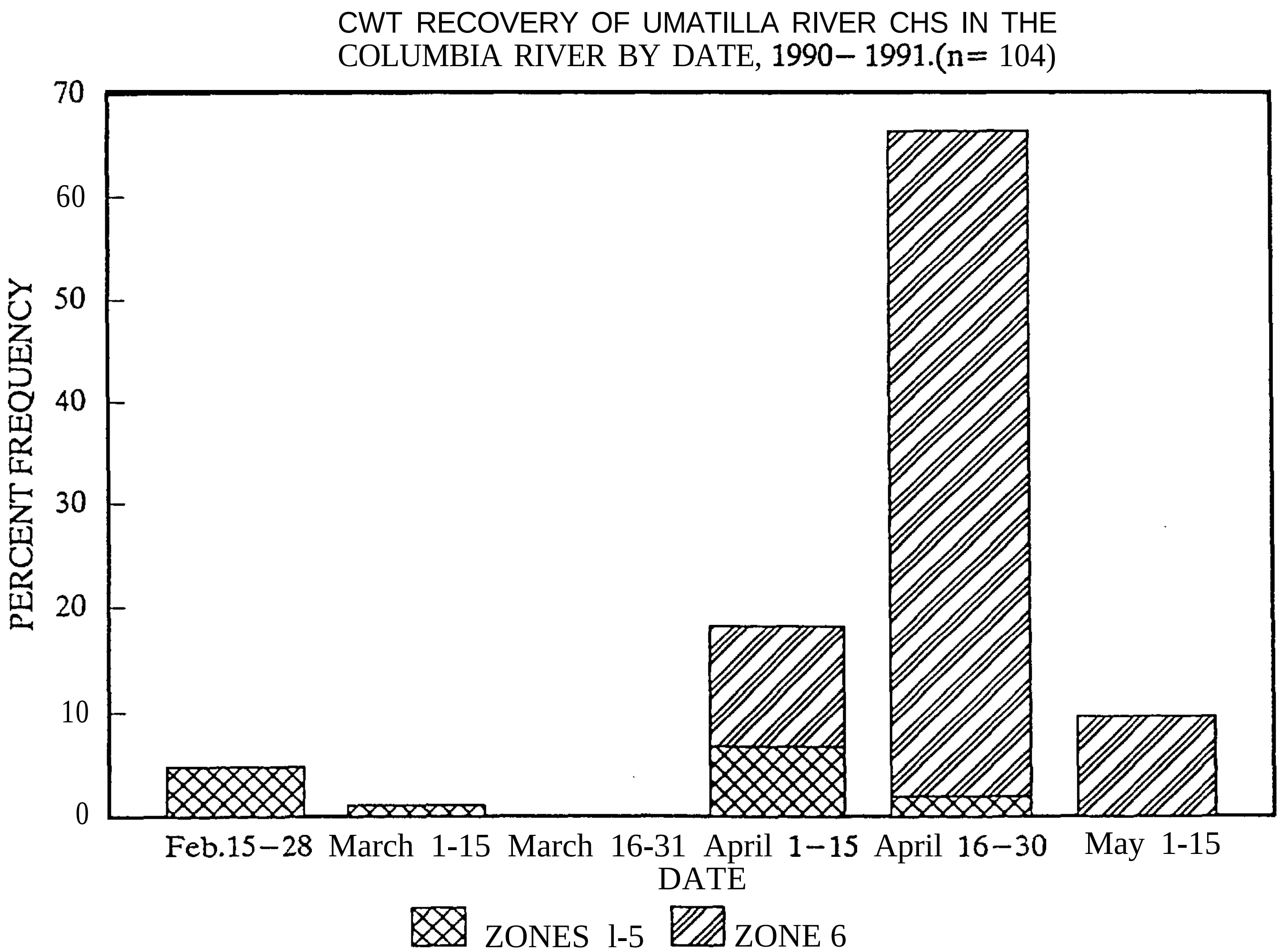

CWT RECOVERY OF UMATILLA RIVER CHS IN THE
COLUMBIA RIVER BY DATE, 1990- 1991.(n= 104)
PERCENT FREQUENCY
70
60
50
40
30
20
10
0
Feb.15-28
March 1-15
March 16-31
April 1-15
April 16-30
May 1-15
DATE
ZONES 1-5
ZONE 6

Figure 14.

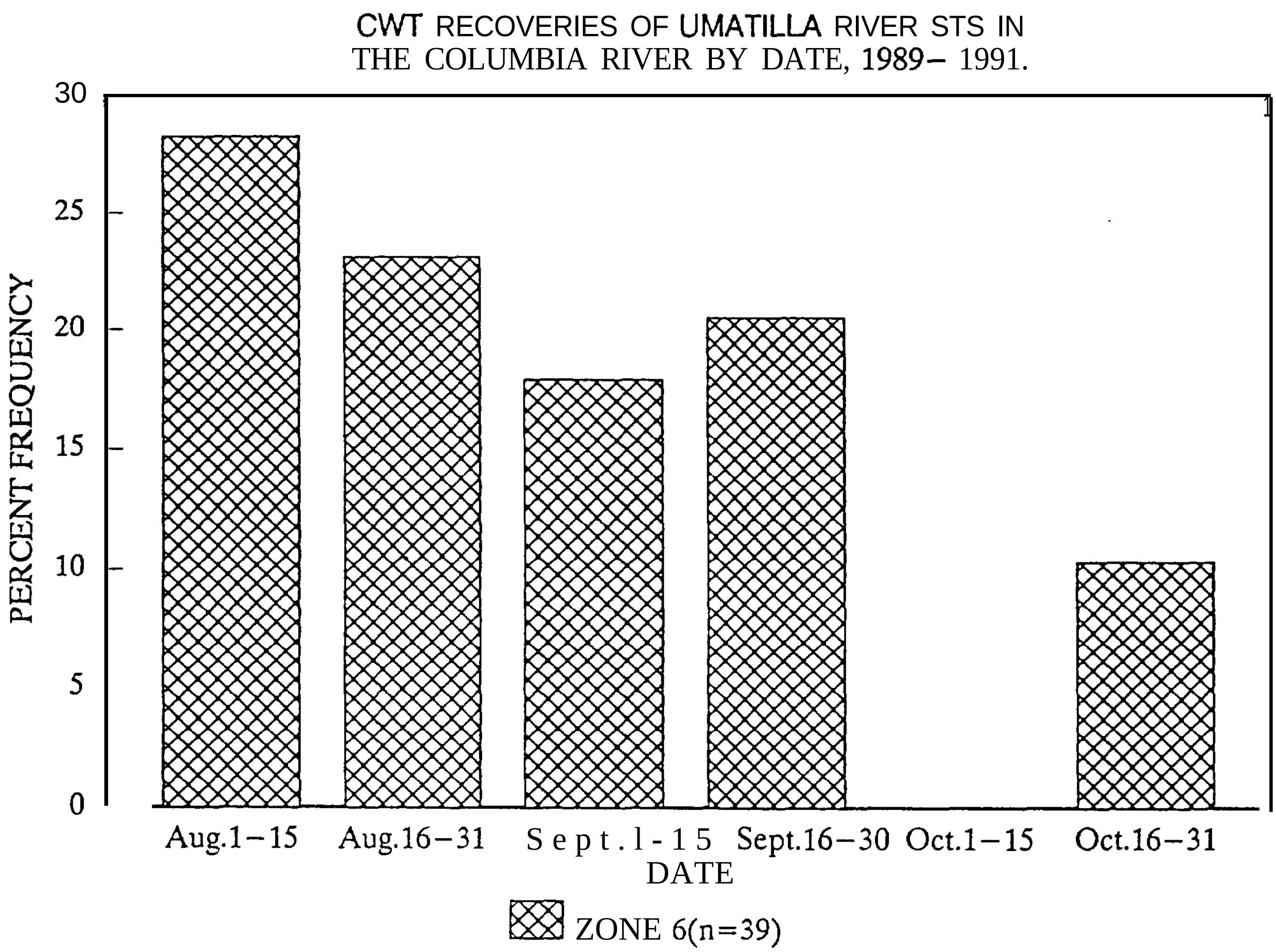
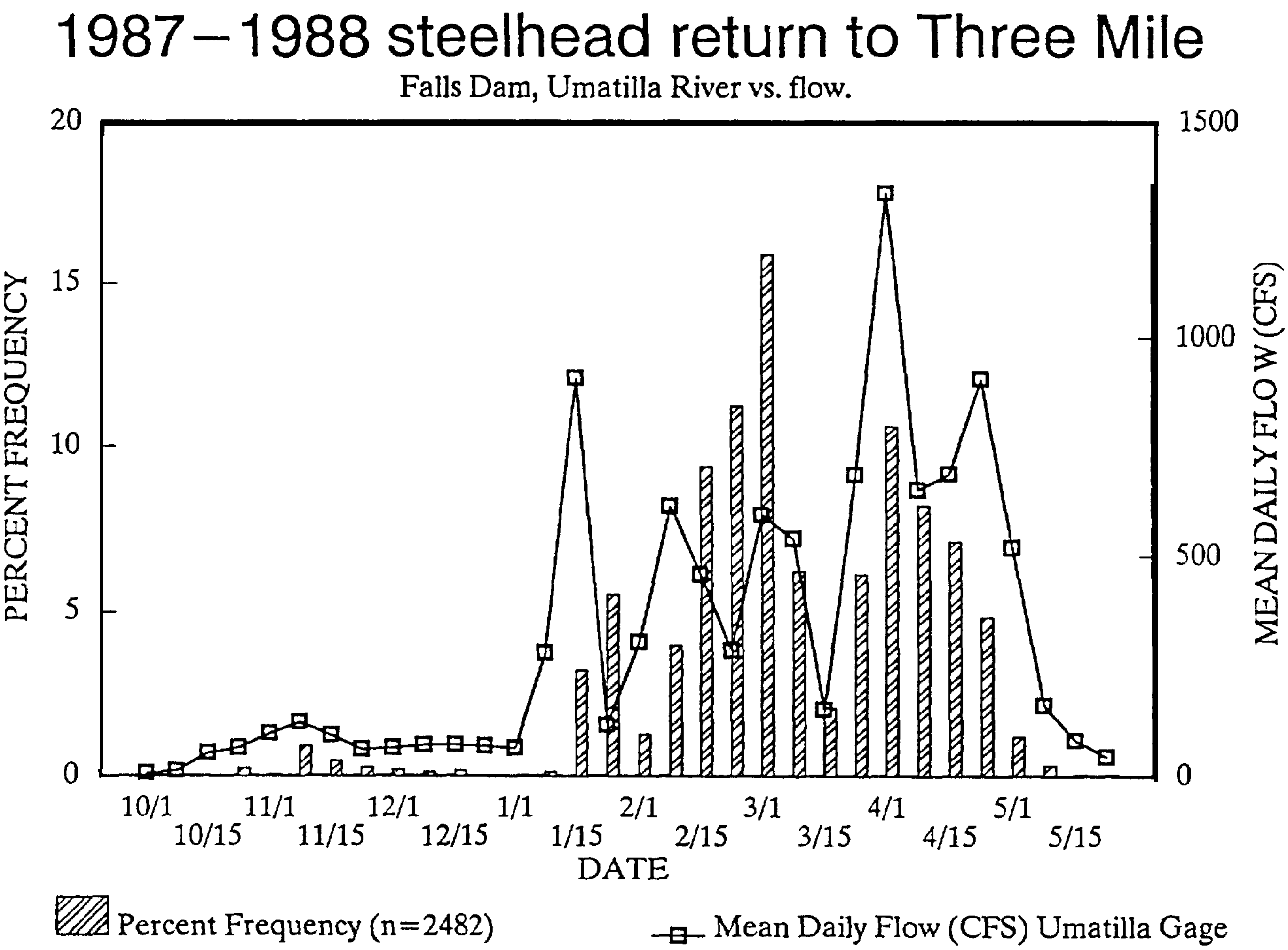
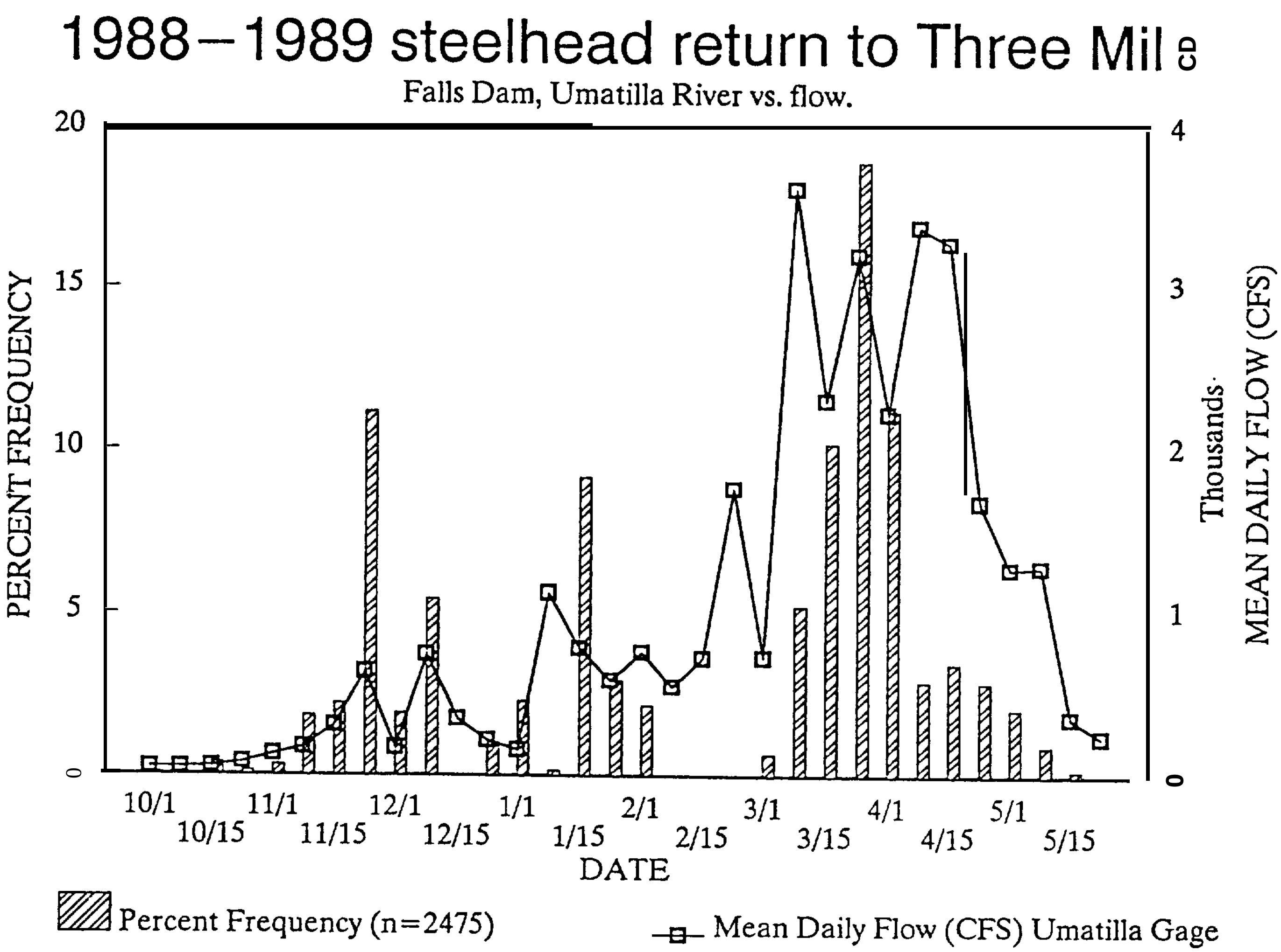

CWT RECOVERIES OF UMATILLA RIVER STS IN
THE COLUMBIA RIVER BY DATE, 1989- 1991.
30
25
20
15
10
5
0
PERCENT FREQUENCY
Aug.1-15
Aug.16-31
Sept.1-15
Sept.16-30
Oct.1-15
Oct.16-31
DATE
ZONE 6(n=39)

Figure 15.



1987–1988 steelhead return to Three Mile
Falls Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
MEAN DAILY FLOW (CFS)
20
15
10
5
0
1500
1000
500
0
10/1
11/1
12/1
1/1
2/1
3/1
4/1
5/1
10/15
11/15
12/15
1/15
2/15
3/15
4/15
5/15
DATE
Percent Frequency (n=2482)
Mean Daily Flow (CFS) Umatilla Gage

Figure 16.



1988–1989 steelhead return to Three Mile
Falls Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
20
15
10
5
0
4
3
2
1
0
Thousands
MEAN DAILY FLOW (CFS)
10/1
10/15
11/1
11/15
12/1
12/15
1/1
1/15
2/1
2/15
3/1
3/15
4/1
4/15
5/1
5/15
DATE
Percent Frequency (n=2475)
Mean Daily Flow (CFS) Umatilla Gage

Figure 17.

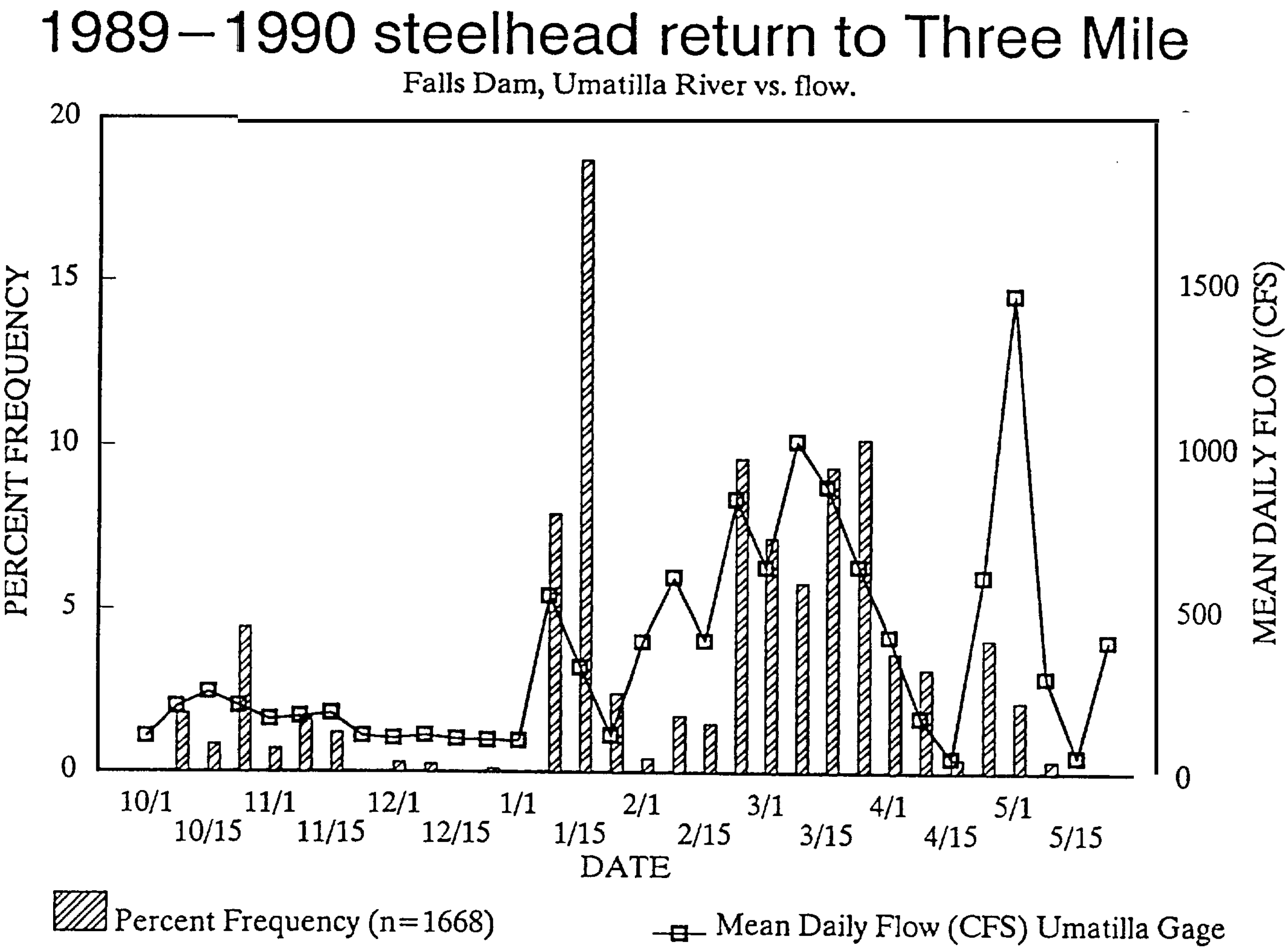
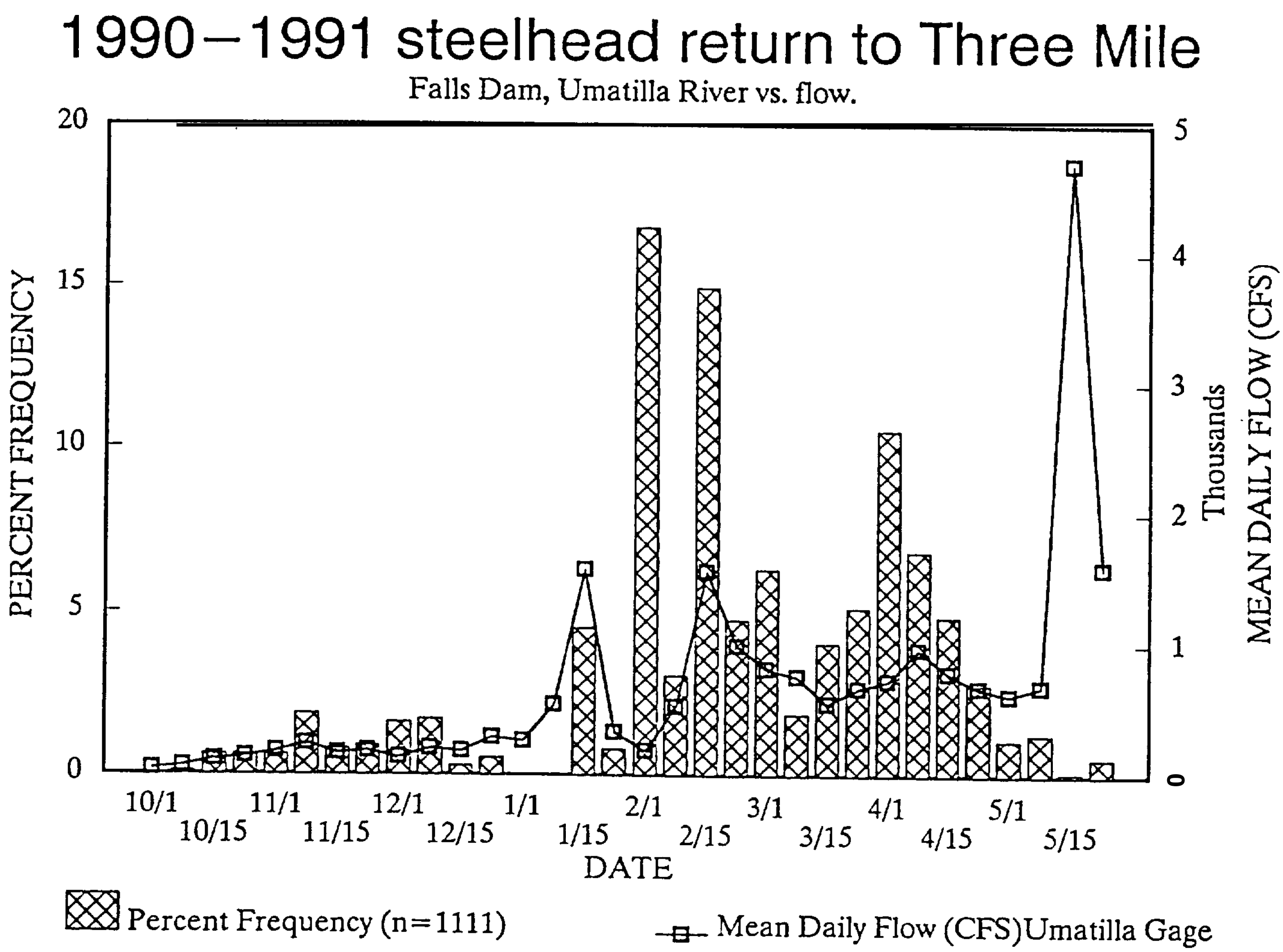

1989–1990 steelhead return to Three Mile
Falls Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
20
15
10
5
0
MEAN DAILY FLOW (CFS)
1500
1000
500
0
10/1
10/15
11/1
11/15
12/1
12/15
1/1
1/15
2/1
2/15
3/1
3/15
4/1
4/15
5/1
5/15
DATE
Percent Frequency (n=1668)
Mean Daily Flow (CFS) Umatilla Gage

Figure 18.

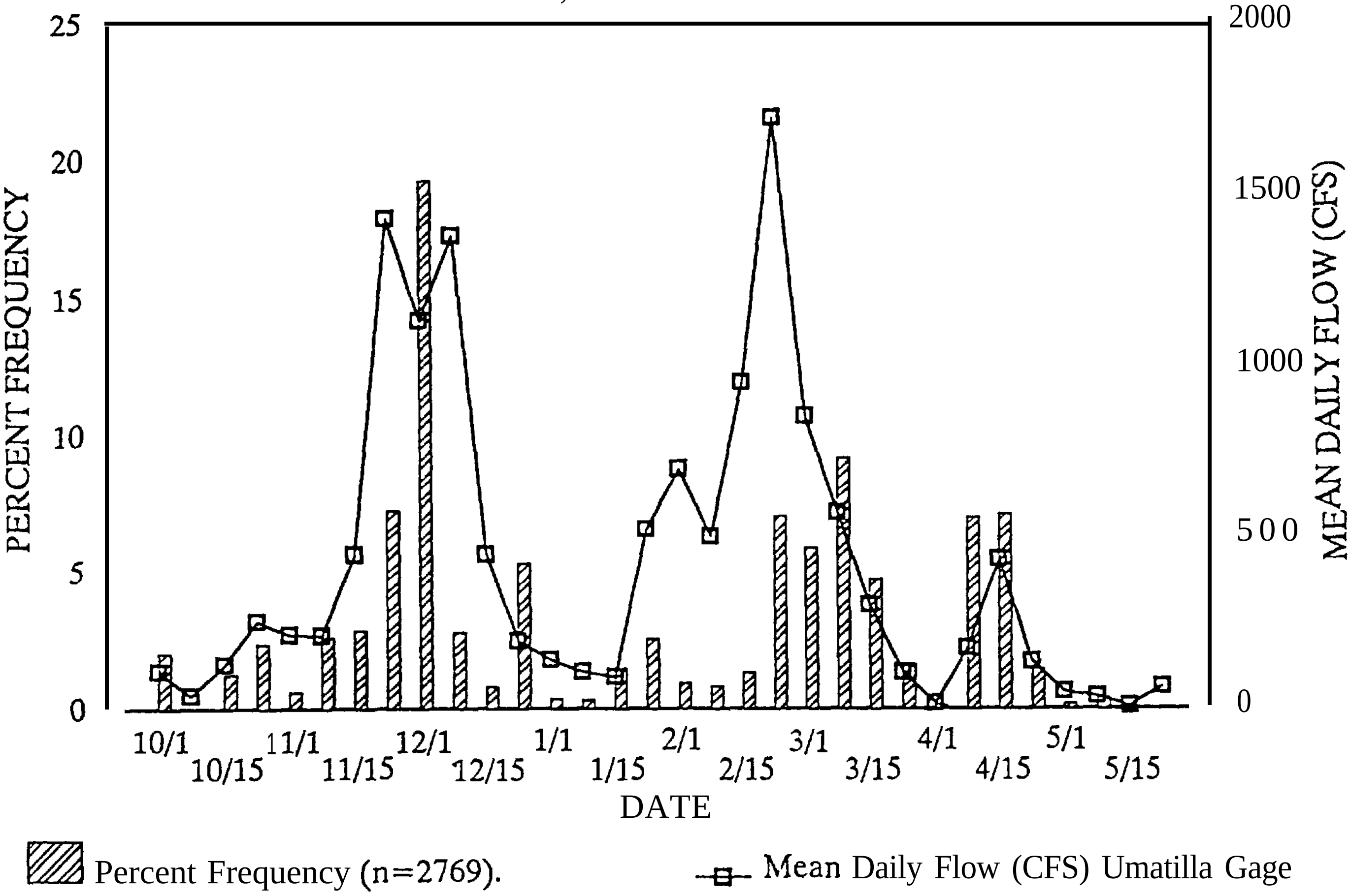


1990-1991 steelhead return to Three Mile
Falls Dam, Umatilla River vs. flow.
PERCENT FREQUENCY
20
15
10
5
0
MEAN DAILY FLOW (CFS)
Thousands
5
4
3
2
1
0
10/1
10/15
11/1
11/15
12/1
12/15
1/1
1/15
2/1
2/15
3/1
3/15
4/1
4/15
5/1
5/15
DATE
Percent Frequency (n=1111)
Mean Daily Flow (CFS)Umatilla Gage

Figure 19.

1991-l 992 steelhead return to Three Mile

Falls Dam, Umatilla River vs. flow



Associated with evaluation of adult SALMONID passage at the irrigation diversions a research proposal should be developed to evaluate the effect of adult salmonid transportation (trap and haul) to various areas above Three Mile Falls Dam vs. volitional migration, on spawning success, when phase two of the Umatilla Basin Project is complete.

Three Mile Dam - West Bank

The west-bank facility at Three Mile Falls Dam should not be operated to "trap and haul" or sample upstream migrant maturing salmonids because of facility limitations. At flow levels experienced during 1991 (700-800 cfs) passage did not appear to be a problem. Passage of various salmonid species at various flow levels will be determined during 1992-1993 and the west bank facility will be operated for approximately 3 weeks in conjunction with the east bank facility and for several days while the east bank is not in operation. If trapping and hauling or sampling are necessary at the west-bank facility the suggestions to eliminate various problems are as follows: the crowder top (sheet metal on top) needs to be cut off or V notch gate screw shortened, the V notch horizontal bars need to be narrower to retain fish in the trap (temporary modifications have been made by CTUIR), install an automatic stop on the horizontal crowder. The flow to the ladder must be shut off and fish need to be dipnetted out of the trap, the backlight chamber needs to be sealed if video enumeration of the escapement is conducted when the facility operates in the bypass mode.

Adult Injury Rates and Escapement through the lower river to Three Mile Falls Dam

Injuries were not observed on maturing salmonids captured at Three Mile Falls Dam during average flows during the fall of 1991 and spring of 1992, as were observed on spring chinook salmon during April and May of 1991. The steepass entrance angle was changed before the adult migration in September, 1991 and few injuries have been observed in the holding pond since that time (Brian Zimmerman, personal communication). Injuries were serious at low water levels when the holding pond pump became non- operational and fish had to be trapped in the top step of the ladder. In 1992 spring chinook adults that migrated up the Umatilla River at 40 cfs had many abrasions and bruises on their ventral surfaces.

Injury of upstream migrant maturing salmonids at and below Three Mile Falls Dam should cease to be a problem when the Umatilla Basin Project is completed.

It appears that the removal of the entrance V which had precluded entrance of large adult salmonids in 1989 and 1990 and higher flows in November permitted a higher percentage of the fall chinook salmon return to migrate to Threemile Falls Dam rather than spawn in the marginal spawning habitat below the dam.

Homing to and Passage in the Umatilla River

Precise homing of Umatilla River salmonids to the Umatilla - Columbia River confluence is probably a combination of juvenile imprint at release (juveniles are reared off-site) and adequate amount and timing of attraction flow as the adults return above John Day Dam. Straying has been minimal in the Umatilla River spring chinook salmon and steelhead enhancement programs but has been very severe in certain groups of fall chinook and coho salmon. To minimize straying of fall chinook salmon juveniles should be reared to age 1+ and acclimated at Bonifer or Minthorn, or released at age 0+ near rivermile 80 (Fred Gray's). Direct release of age 0+ fall chinook salmon at Fred Gray's is probably the best compromise between a good imprint and not severely impacting the natural salmonid production area further upriver. Direct releases should not be conducted in the lower river because of very high straying rates.

Passage (physical upstreammovement) of maturing salmonids from the Umatilla-Columbia River confluence to Three Mile Falls Dam is not generally a problem except at very low flows (less than 50 cfs) and probably very high flows. Although maturing salmonids can physically migrate at these minimal flows, ventral abrasions are evident, water temperatures can rapidly warm to lethal limits (75°F') and many returning salmonids stray.

It appears that the amount of attraction water necessary for precise homing (if the fish has been properly acclimated) is much greater than flows necessary for physical passage in the lower Umatilla River below Three Mile Falls Dam.

Based on available data it appears that flows were adequate for precise homing during the spring of 1990 and 1991 and were inadequate for precise homing during the fall of 1989-1991 and spring of 1992. Spring flows during 1990 and 1991 were often 400-500 cfs or greater and during the spring of 1992 and falls of 1989-1991 flows were often less than 100 cfs and seldom above 250 cfs. High water temperatures may delay entry timing but they probably do not effect ability to home. Higher flows associated with the Umatilla Basin Project should decrease potential migration delays because of warm water.

Usage of adaptive water management will be necessary upon completion of phase two of the Umatilla Basin Project to determine attraction flows necessary for precise Based on current data it appears that we need to have 200-250 cfs from September 1 through November for maturing fall returning salmonids. Probably the amount of flow necessary at the mouth of the Umatilla River for precise homing would be directly related to the flow in the mainstem Columbia River. When Columbia River flows are high, such as during spring runoff, the amount of Umatilla River flow necessary for homing would need to be greater than in the fall when Columbia River flows are low.

LITERATURE CITED

Confederated Tribes of the Umatilla Indian Reservation and Oregon Department of Fish and Wildlife (CTUIR and ODFW0. 1990.

Columbia Basin System Planning, Umatilla Subbasin, September, 1990. Submitted to Northwest Power Planning Council and Columbia Basin Fish and Wildlife Authority, Portland, Oregon.

Appendix A. Coho salmon escapement sampling below Threemile Falls Dam, Umatilla River, 1991.

Date	Length	Sex	Comments	Spawning Status
10/30/91	560	F	China Hole Area 9150447	PM
10/30/91	560	F	China Hole Area	PM
10/30/91	610	M	China Hole Area	PM
10/30/91	510	M	China Hole Area	SO
10/30/91	610	F	China Hole Area	Rl000
10/30/91	585	F	China Hole Area	SO
10/30/91	510	F	China Hole Area	PM
10/30/91	585	F	China Hole Area	PM
10/30/91 I	460	M	China Hole Area	PM
10/30/91	460	M	China Hole Area	PM
10/30/91	485	M	China Hole Area 91J0448	PM
10/30/91	430	M	China Hole Area	PM
11/4/91	580	M	Chinaman's Hole Slough	SO
11/4/91	515	M	Chinaman's Hole Slough	PM
11/5/91	565	M	Threemile Dam to Chinaman's Hole H_2O 45F	SO
11/5/91	450	F	Threemile Dam to Chinaman's Hole H_2O 45F	?
11/5/91	590	M	Threemile Dam to Chinaman's Hole H_2O 45F	SO

Appendix A. cont.

11/5/91	555	F	Threemile Dam to Chinaman's Hole H_2O 45F	so
11/5/91	620	M	Threemile Dam to Chinaman's Hole H_2O 45F	so
11/5/91	545	F	Threemile Dam to Chinaman's Hole H_2O 45F	R100
11/5/91	540	F	Threemile Dam to Chinaman's Hole H_2O 45F	R150
11/5/91	540	M	Threemile Dam to Chinaman's Hole H_2O 45F	so
11/5/91	570	F	Threemile Dam to Chinaman's Hole H_2O 45F	PM
11/5/91	600	F	Threemile Dam to Chinaman's Hole H_2O 45F	so
11/5/91	440	M	Threemile Dam to Chinaman's Hole 91J1031	so
11/5/91	460	M	Threemile Dam to Chinaman's Hole 9151032	so
11/5/91	530	F	Threemile Dam to Chinaman's Hole	PM
11/5/91	450	M	Threemile Dam to Chinaman's Hole	so
11/5/91	490	F	Threemile Dam to Chinaman's Hole	PM
11/5/91	Approx. 570	M	Threemile Dam to Chinaman's Hole	?
11/5/91	570	M	Threemile Dam to Chinaman's Hole	so

Appendix A. cont.

11/5/91	*550*	F	Threemile Dam to Chinaman's Hole 9150817 clipped?	PM
11/5/91	*535*	F	Threemile Dam to Chinaman's Hole	PM
11/5/91	*570*	F	Threemile Dam to Chinaman's Hole	R150
11/5/91	*400*	M	Threemile Dam to Chinaman's Hole	PM
11/5/91	*615*	M	Threemile Dam to Chinaman's Hole	PM
11/5/91	*480*	M	Threemile Dam to Chinaman's Hole	PM
11/5/91	*515*	F	Threemile Dam to Chinaman's Hole 9150816	PM
11/5/91	*530*	F	Threemile Dam to Chinaman's Hole	R50
11/5/91	*530*	F	Threemile Dam to Chinaman's Hole	PM
11/6/91	595	M	China slough	PM
11/6/91	*570*	F	China slough	PM
11/6/91	*540*	F	China slough	PM
11/6/91	*570*	F	China slough	SO
11/6/91	*535*	F	China slough	PM
11/7/91	*575*	F	China slough	PM
11/7/91	590	F	China slough 91J0803	R30
11/7/91	485	F	China slough	R60
11/7/91	*565*	F	China slough	PM
11/7/91	*540*	F	China slough	---
11/7/91	*545*	F	China slough	---

Appendix A. cont.

11/7/91	570	M	China slough	SO
11/7/91	530	F	China slough	---
11/13/91	515	---	China slough	---
11/13/91	---	---		---
11/13/91	520	F		R300
11/13/91	515	M		SO
11/13/91	515	M		SO
11/13/91	580	M		SO
11/13/91	565	F		SO
11/13/91	555	F	91J1033	R150
11/13/91	565	F		SO
11/13/91	485	F		R50
11/13/91	525	M		---
11/13/91	525	F		R75
11/13/91	560	F		SO
11/13/91	590	F		SO
11/13/91	650	M		SO
11/13/91	540	F		SO
11/13/91	570	F		SO
11/13/91	580	M		PM
11/13/91	560	F		SO
11/13/91	550	F		R300
11/13/91	500	F		SO
11/13/91	555	F		R50
11/13/91	555	F		SO
11/13/91	585	F		R75
11/13/91	565	F		R50
11/13/91	525	F		R100
11/13/91	515	M	9151049	SO
11/13/91	605	M	9151050	PM
11/13/91	610	M	9151051	SO
11/14/91	415	F	Chinaman's Hole Slough	PM

Appendix A. cont.

11/14/91	630	M	Chinaman's Hole Slough	PM
11/14/91	520	M	Chinaman's Hole Slough	PM
11/14/91	540	F	Chinaman's Hole Slough	PM
11/14/91	510	F	Chinaman's Hole Slough	PM
11/15/91	580	M	Chinaman's Hole Slough	PM
11/21/91	550	F	9151052 Chinaman's Hole Slough	R38
11/21/91	550	F	Chinaman's Hole Slough	PM
11/25/91	580	F	Chinaman's Hole Slough	R60
11/25/91	560	F	H_2O Temp 45F	PM
11/25/91	460	F		PM
11/25/91	615	M		PM
11/25/91	565	F		SO
11/25/91	555	F		SO
11/25/91	---	---		---
11/25/91	470	M		?
11/25/91	510	F		SO
11/25/91	560	M		?
11/25/91	270	M		PM
11/25/91	340	M		SO
12/18/91	585	M	H_2O 38F	SO
12/18/91	---	---		---
12/18/91	---	F		SO
12/18/91	---	F		PM
12/18/91	---	F		PM

Appendix B. Fall Chinook salmon escapement sampling below Threemile Falls Dam, Umatilla River, 1991.

Date	Length	Sex	Comments	Spawning Status
11/13/91	780	F		SO
11/25/91	810	M		PM
11/25/91	---	---		---
11/25/91	735	---		---
11/25/91	680	F		R150
11/25/91	880	F	9151030 7-40-39	SO
11/25/91	685	M		PM
11/25/91	785	F	9131023 7-40-39	SO
11/25/91	640	F		?
11/25/91	720	F		R50
11/25/91	670	M		SO
11/25/91	745	F	9151034 7-40-38	SO
11/25/91	735	F		R1000
11/25/91	735	---	9151022 7-40-23	---
11/25/91	815	---		---
12/18/91	740	F	9151017	SO

Appendix C. Fall chinook and coho salmon escapement surveys below Threemile Falls Dam on the Umatilla River 1989-1991.

			Live Fish				Dead Fish			
Year	Miles Surveyed	Redds	CHF	Coho	Unid	Total	CHF	Coho	Unid	Total
1989	2.5	56	8	4	15	27	92	52	17	161
1990	2.5	53	15	9	11	35	120	5	8	133
1991	2.5	35*	16	68	0	84	16	107	1	124

*Excludes Chinaman's Slough